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Washington State
Department of Transportation

Memorandum

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TO: Michael Cummings, WSDOT Urban Corridors Office

FROM: Donald Samdahl

DATE: August 9, 2002

RE: Revenue Estimates for Managed Lanes on I-405

As part of the assessment of Managed Lane feasibility on I-405, the project team conducted a sketch-level assessment of potential revenues that could be generated with a pricing strategy. The purpose of this analysis was to provide an order-of-magnitude estimate of revenues that could be considered during the decision process on the managed lane concept.

The following assumptions were included in the analysis:

- Two managed lanes in each direction would operate along I-405 between Renton and Bothell
- 2020 Horizon Year
- Operation of the managed lanes would be a variation of Concept #2 (refer to *I-405 Managed Lane Evaluation,* Technical Memorandum, August 2002). Concept #2 operations include peak period limitations to HOV 2+ users, while all users would be eligible for the managed lanes during off-peak periods. For the pricing option summarized in this memorandum, excess capacity during peak periods would be sold to other users. HOV 2+ users would not pay a toll, nor would off-peak tolls be charged.
- The managed lanes would be filled to optimal capacity during peak periods. In essence, it is assumed that the price would be set such that an optimal flow rate would be maintained.
- No Managed Lane expenses were included.

The revenue estimates were produced using the following steps:

1. Estimate peak period (3 hour AM and PM) 'spare capacity' within the managed lanes. Four locations along the corridor were analyzed in each direction of travel. Spare capacity was estimated from traffic distributions in the *Managed Lane Evaluation* report. **Table 1** documents the volumes that were estimated, along with the segment length to which the volumes were applied.

2. Estimate toll rates per mile that matches with general traffic congestion in the non-managed lanes. The range of toll rates was assumed to be $0.10 to $0.40 per mile, using the comparable toll costs documented in the I-405 managed lane study. (Refer to **Figure 1**). Congestion levels were examined for the four screenline locations shown in Table 1. A reasonable toll rate was estimated using professional judgment for each segment and time period using these data.
3. Compute daily toll revenues for the peak period pricing of Single Occupant Vehicles. Table 1 shows that the daily revenues could be in excess of $100,000 (year 2000 dollars excluding expenses)
4. Compute annual revenues by multiplying the daily revenues by 260 days. This resulted in an annual estimate of around $30 Million revenues generated annually by the year 2020.

Conclusions

The managed lane revenue estimates are considered to be relatively conservative (i.e. low) for the following reasons:

- No charge is imposed for HOV's
- No off-peak or weekend charges are imposed
- The revenues are expressed in Year 2000 dollars rather than year of operation dollars

Offsetting these estimates is the fact that operating and maintenance costs for the managed lanes have not been factored into the equation.

Using these caveats and realizing the sketch-planning nature of the analysis, we estimated a range of net annual revenue of around $20 to $40 million per year in 2014 (which was the year selected in the *Regional Toll Analysis* as a mid-point for I-405 implementation).

Additional detailed analysis would be required along I-405 to determine the dynamics of pricing effects on demand and identification of optimal toll rates.

Table 1- I-405 Managed Lane Revenue Worksheet

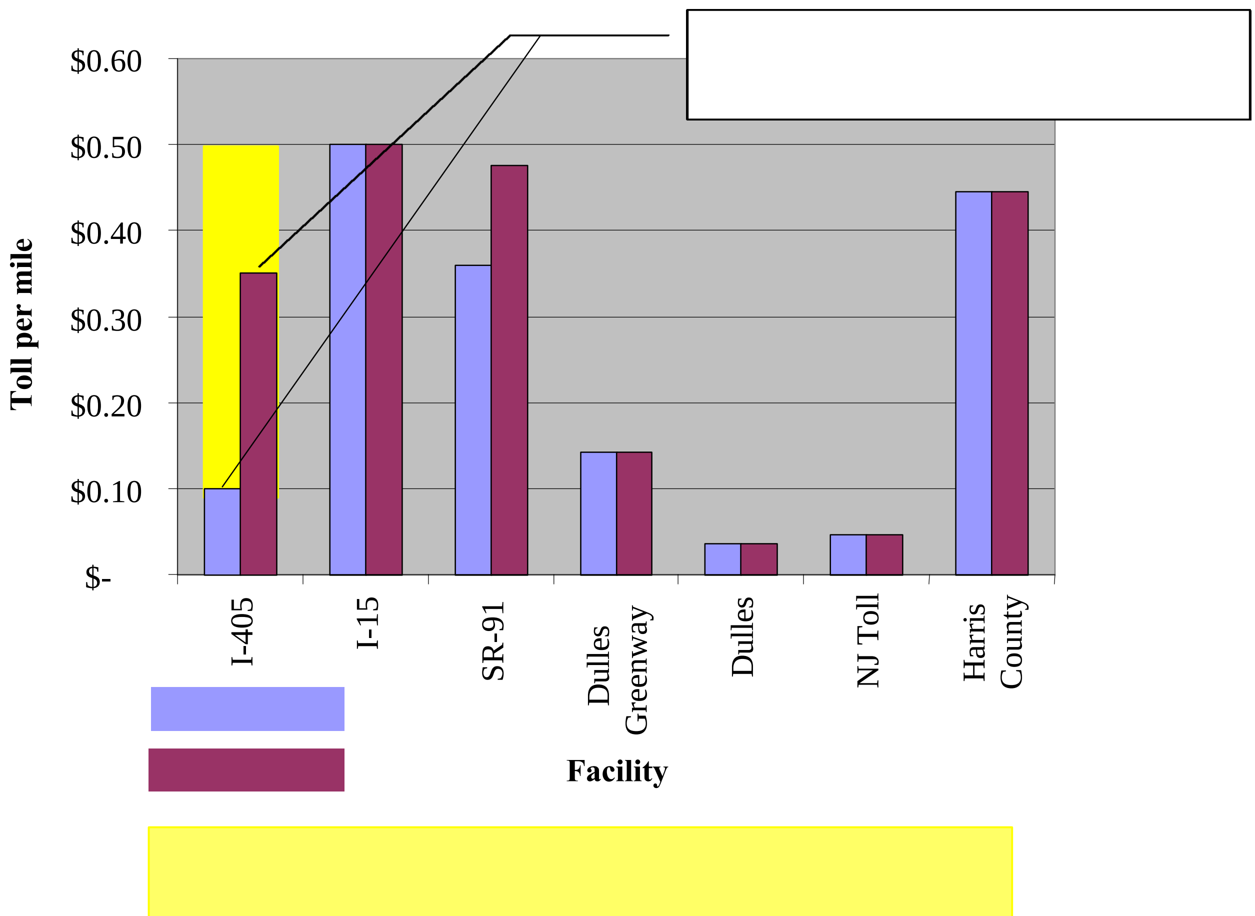
	AM Peak Period (3 hours)							
Segment	NB Volume	Mi	$/mi	$	SB Volume	Mi	$/mi	$
Bothell	9,000	5	$ 0.10	$ 4,500	6,000	5	$ 0.20	$ 6,000
Kirkland	9,000	6	$ 0.10	$ 5,400	1,500	6	$ 0.20	$ 1,800
Bellevue	3,600	4	$ 0.20	$ 2,880	6,000	4	$ 0.30	$ 7,200
Newcastle	4,500	7	$ 0.30	$ 9,450	9,000	7	$ 0.20	$ 12,600

	PM Peak Period (3 hours)								
Segment	NB Volume	Mi	$/mi	$	SB Volume	Mi	$/mi	$	Total $$
Bothell	6,000	5	$ 0.35	$ 10,500	8,400	5	$ 0.20	$ 8,400	29,400
Kirkland	1,500	6	$ 0.40	$ 3,600	6,000	6	$ 0.25	$ 9,000	19,800
Bellevue	4,500	4	$ 0.40	$ 7,200	600	4	$ 0.40	$ 960	18,240
Newcastle	6,900	7	$ 0.35	$ 16,905	3,600	7	$ 0.40	$ 10,080	49,035

3 hour peak periods (2020)
$/mi based upon ranges shown in Figure 1 for optimal toll rates

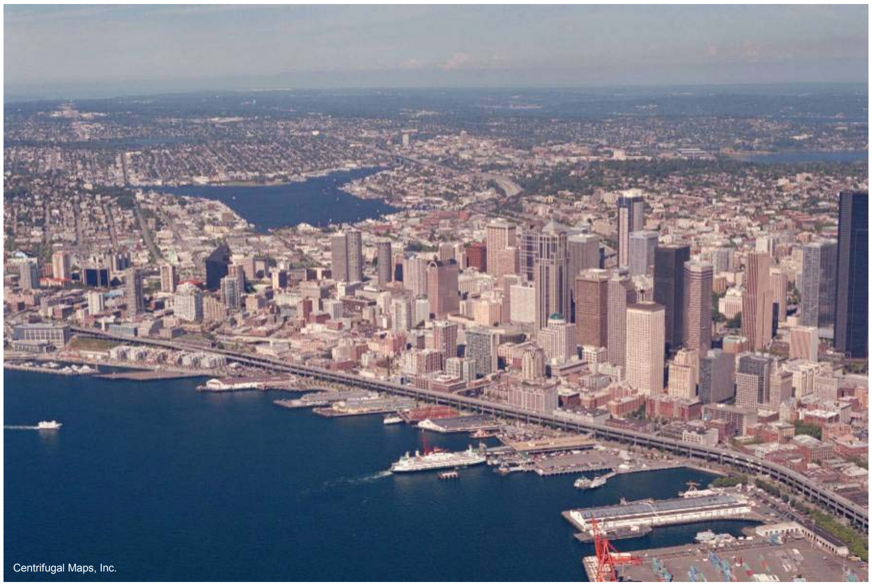
Daily Revenue	$	116,475
Annual Revenue (260 days)	$	30,283,500

Figure - Comparative Toll Costs



SR 99: ALASKAN WAY VIADUCT PROJECT

Toll Feasibility Study



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Washington State Department of Transportation

City of Seattle

June 2002

SR 99: Alaskan Way Viaduct Project

Toll Feasibility Study

Agreement No. Y-7888

Task E 10.2.3

The SR 99: Alaskan Way Viaduct Project is a joint effort between the Washington State Department of Transportation (WSDOT) and the City of Seattle. To conduct this project, WSDOT contracted with:

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DISCLAIMER

This Report was prepared by Parsons Brinckerhoff (PB), in accordance with an agreement with the Washington State Department of Transportation (WSDOT). This Report is subject to the terms and conditions contained within the consulting agreement, and is meant to be read as a whole and in conjunction with this disclaimer.

The Report, information contained herein, and any statements contained within the Report, are all based upon information provided to PB by, and obtained from, the Washington State Department of Transportation (WSDOT), the Puget Sound Regional Council (PSRC), and other sources. PB makes and provides no assurance as to the accuracy of any such information or any conclusions that are based thereon, and bears no responsibility for the results of any actions taken on the basis of this Report.

This Toll Feasibility Study for the Alaskan Way Viaduct (AWV) Project was prepared using the best available information and tools at the time of writing; however, the timing is such that this report does not benefit from work-in-progress refinements to the PSRC model, which when completed, will make the model better suited to toll modeling. In addition, other factors may have changed since the time this report was prepared. Assumptions and specifications regarding the proposed AWV toll facility characteristics were developed in collaboration with WSDOT, and may or may not represent most likely scenarios regarding implementation and timing.

The traffic and revenue results presented herein are provided for feasibility considerations and to enlighten further policy discussions, and should not be construed as investment-grade projections. Better tools would need to be developed and applied with rigorous methods including independent review of assumptions at every stage to produce investment-grade projections suitable for securing a credit rating and obtaining toll revenue bond financing.

In the preparation of this Report and the opinions contained herein, PB makes certain assumptions with respect to such conditions that may exist or events that may occur that are subject to change in the future. These assumptions are made for purposes of modeling an AWV toll facility and identifying a range of potential revenue, and are not intended to reflect any official decisions regarding new highway investments. Although PB believes these assumptions to be reasonable for the purposes of this Report at the time of writing, they are dependent upon future events, and actual conditions may differ from those assumed.

EXECUTIVE SUMMARY

With a list of transportation needs that far outstrips available funding, and increasing traffic congestion adversely impacting our region's livability, there is a heightened call for new revenue sources to finance transportation infrastructure. User fees in the form of tolls have been a key element of this discussion, especially for the Puget Sound region's large scale "mega-projects". Tolling has a key advantage over other transportation funding sources, in that it creates a direct linkage between project financing and those who use the roadway. With sufficient autonomy in setting prices, this gives the toll road owner/operator the unique ability to manage traffic flows, prevent congestion, and thus, assure the traveling public of an efficient and reliable route.

One candidate project for user fees is the proposed replacement of the SR-99 Alaskan Way Viaduct and waterfront seawall in downtown Seattle. A combination of age and damage from the Nisqually earthquake in early 2001 suggests that replacement of the roadway and seawall is a more feasible and forward-thinking option than repairing and retrofitting the existing viaduct. Regardless of the approach, the costs of fixing or replacing the Alaskan Way Viaduct (AWV) are likely to be substantial, and scarce funding further warrants a study of the feasibility of tolling.

Study Objectives and Methods

The objective of this study is to model the existing Alaskan Way Viaduct and a representative replacement alternative with tolling in order to develop a range of projected annual revenue. The resulting revenue projections are intended to inform the policy discussion and assist decision-makers in determining if tolling has sufficient revenue potential and/or is an appropriate congestion management tool to merit further research, modeling and analysis.

For the existing facility, it was assumed that tolls would be applied over 4.02 miles, from the SR-99 interchange with Spokane Street in the south to the Battery Street Tunnel portal in the north at Denny Way. Alternative D was used as representative of a maximum build replacement alternative for modeling purposes. In this case, tolls would be applied over 4.93 miles due to a different alignment including a northern terminus at a new tunnel portal at Roy Street.

The Puget Sound Regional Council's regional travel demand model and forecasting procedures were adapted for analyzing the AWV as a toll facility, and represent the practice methods for feasibility purposes currently available. On an unpriced roadway, users consider only their own travel time costs, and not the delay costs they impose on other users. This behavior tends to result in roadway over-consumption and congestion, especially during peak times. The modeling approach employed seeks to implement the economically efficient toll, defined as the external time cost that an additional vehicle imposes on all other vehicles in the traffic stream. As the volume on a roadway approaches capacity, each new vehicle adds an increasing external delay effect on all the others. As such, the economically efficient or "optimal" toll also rises at an increasing rate to maintain good flow conditions, by inducing a sufficient number of would-be road users to seek alternative routes or times to travel.

The regional model adds this external time cost to the individual time cost perceived by each user, and then attempts to assign trips to minimize the overall network travel time. The resulting toll rates, estimated as time costs per mile for three daily periods — peak period/peak direction, peak period/reverse direction, and midday period/both directions — are converted to monetary units by applying the average willingness to pay for delay reduction, expressed in dollars per hour.[1] Research has shown that this value of time is approximately one-half of the average wage rate. For purposes of this study, the value of time was varied between one-third and one-half of the average wage rate for King County to create a range of monetary toll rates. In addition, optimal tolls were computed for both the existing facility and the representative replacement alternative. The overall range of toll rates by time period and direction are shown in Table ES - 1 for opening year (2009) demand levels, along with the total costs for end-to-end travel. All amounts have been inflated to 2009 dollars and reflect the combined results of the two alternatives considered.

Table ES - 1
Range of Toll Rates & Travel Costs by Time Period/Direction in 2009

Time of Day &	*Range of Toll Rates (per mile)*			*Typical End-to-End Travel Cost*		
Travel Direction	***Min***	***Average***	***Max***	***Peak Dir***	***Rev Dir***	***Average***
Peak Periods (6 - 9 AM & 3 - 7 PM)	$0.04	$0.10	$0.24	$0.44	$0.18	$0.31
Midday / Evening (9 AM - 3 PM & 7 - 9 PM)	$0.04	$0.04	$0.04			$0.16
Night (9 PM - 6 AM)	*— Average Traffic Volumes Too Low to Make Tolling Feasible —*					

Note: All amounts are for year of opening demand levels in 2009 dollars.

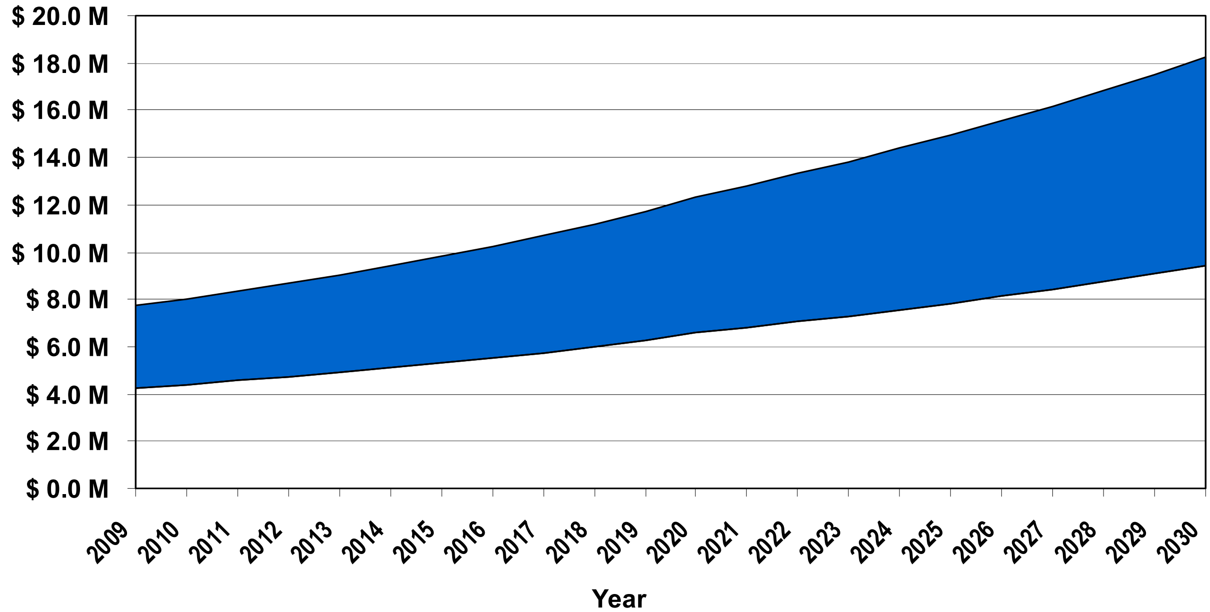
Revenue Projections and Considerations

The above optimal toll rates were applied to the with-toll modeled traffic volumes, expressed as vehicle miles traveled by time period and direction, to yield a range of toll revenue forecasts. This range was widened a bit further by considering whether or not tolls were charged on weekends during the day at the midday/off-peak rate. Figure ES - 1 presents this range of projected revenue, in inflated or year of collection dollars, from the opening year 2009 through the model horizon year of 2030.

The opening year annual revenue "bookends" stretch from approximately $4.3 million to $7.8 million in 2009 dollars. This range forms a boundary around variation in the assumptions for value of time, facility design and access characteristics, and weekend tolling. Furthermore, it may take a few months for opening year demand to ramp-up to the forecast expectations, and thus, initial revenue may be closer to the low half of the spectrum.

[1] Demand during night hours proved to be insufficient to generate tolls much above zero, and thus, night tolls were excluded.

Figure ES - 1
Toll Revenue Range in Inflated Dollars over Both Alternatives



Note that nominal annual revenue is shown growing at an increasing rate over time. This reflects a rising set of optimal toll rates for the AWV replacement facility, which are assumed to escalate for two reasons:

1. Growth in traffic demand will necessitate an increasingly higher optimal toll in order to elicit the appropriate travel behavior and diversion to maintain an economically efficient traffic flow; and

2. Over time, general inflation will increase the average wage rate, and thus users' value of time, the latter of which drives the calculation of the optimal toll rate.

This is an important outcome, and one that will undoubtedly create some political challenges. Though the AWV is not currently that congested, failure to increase optimal toll rates for both inflation and rising demand over time, particularly during peak periods, could eventually lead to the occurrence of congestion on the AWV replacement facility. At a certain point, increased congestion could reduce the efficiency of the facility, and negate part of the reason why tolls are imposed in the first place.

While the methods employed provide ranges for economically efficient tolls and the resultant traffic and revenue, they do not give any indication of the elasticity of demand, and thus cannot be used to pin down how much demand and revenue will change if the toll rates are altered.[2]

[2] During peak periods, the economically efficient tolls will generally tend to approximate the revenue maximizing toll rates. However, the appropriate tools to test this premise and measure the sensitivity of demand to different tolls by various market segments do not exist at this time. A section of the main report outlines the steps for creating the tools necessary to estimate demand elasticities and prepare "investment grade" revenue forecasts.

Indeed, a much more comprehensive modeling effort, involving substantial market survey research and independent review of all model inputs, would be required to rigorously model demand and produce "investment grade" traffic and toll revenue forecasts. Nonetheless, the resulting range of annual revenues likely encases the true revenue potential, and can thus help decision makers ascertain if additional, more resource-intensive market research and modeling make sense.

Summary of Findings

There is sufficient travel demand and congestion in the Alaskan Way Viaduct corridor to warrant the application of congestion pricing via tolls. At the same time, the relatively short distance combined with the existence of several substitute parallel routes and a lack of peak period reverse direction and off-peak period demand limits the ultimate revenue potential that could be achieved by creating a more extended north-south urban corridor.

Moreover, the success of implementing pricing on any single roadway, including the AWV, will likely be enhanced to the extent that other facilities within the regional highway system adopt pricing management techniques and integrated electronic payment methods. In any event, tolling the AWV will cause some diversion to City streets and I-5, particularly in the absence of a system-wide approach to pricing.

The physical needs for electronic tolling and/or cash payment toll collection have not been analyzed herein. However, there will likely be some significant physical and geographical challenges to implementing a cash payment toll collection option, particularly with multiple access and egress points in both travel directions.

For the Alaskan Way Viaduct or its replacement, application of the economically efficient or optimal per-mile toll rates using only electronic toll collection can be expected to generate gross annual revenue within the range of $4.3 to 7.8 million in the opening year of 2009.

This estimated range excludes probable demand ramp-up effects that would occur during the initial months of operation. Actual revenue will depend on users' values of time as indicative of willingness to pay, and the time periods for which tolls are to be charged. Demand and gross revenue would be approximately 10% higher with a delay-free cash payment method, but manual toll collection congestion impacts and costs may offset much of the additional revenue.

The optimal toll rates will need to increase periodically due to both inflation and growing travel demand, if the roadway is to be managed to yield economically efficient network traffic levels to minimize congestion. Regular toll increases will require that the operating objectives and management policies of the facility be well established and clearly communicated to the public and policy-makers.

Toll diversion to other routes, modes, time of day as well as trip chaining and elimination is expected to average from 13% to 17% across alternatives and analysis years. Localized diversion between various access points may vary outside of this range.

The optimal toll rates seek to minimize overall network travel times. These toll rates are likely to be less than those that would maximize revenue; however, the appropriate research and tools for determining the revenue maximizing tolls do not currently exist. Nonetheless, the revenue maximizing toll structure would likely result in additional diversion and, thus, greater social delay costs due to increased congestion on unpriced facilities.

Each $1 million of annual toll revenue, net of any operating costs, could leverage approximately $7-10 million of capital investment, plus another $1-2 million toward a few years of capitalized debt service costs during construction, via the sale of municipal revenue bonds or similar debt instruments. For the AWV replacement, the spectrum of projected toll revenue equates to a range of capital investment purchasing power with a lower bound of $35 million and an upper bound of $95 million in project costs, including a portion for capitalized debt service.

Exact bond proceeds would depend on debt service coverage requirements, issuance costs, debt terms and duration, and the duration of construction, among other variables.

Toll revenue under Alternative D in 2009 exceeds that of the existing facility by 15%, escalating to 23% by 2030. This is a function of the longer travel distance of Alternative D combined with similar timesavings due to higher design standards. Other build alternatives with similar access points would likely generate toll revenue between these two endpoints.

Design improvements of the build alternatives lead to marginally improved capacity, operating efficiency, and thus, higher demand. This is somewhat offset by longer travel distances, and overall, the build alternatives are likely to result in per-mile toll rates similar to those for the existing facility. However, certain build alternatives may yield somewhat higher revenues, due to the fact that tolls are charged over longer travel distances and for slightly higher traffic volumes.

If the proposed AWV replacement toll facility became part of a larger limited access north-south corridor connecting in with SR-509 in the south and I-5 in the north, then the resulting benefits, demand levels, and thus, toll revenue could be significantly higher.

INTRODUCTION

This report is part of a series of early action efforts addressing the funding and financial issues surrounding the proposed replacement of the SR-99 Alaskan Way Viaduct (AWV). User fees in the form of tolls have been brought to the table as potential source of funding for this project, and this possibility is explored to assist decision-makers in determining if tolling has sufficient revenue potential and/or is an appropriate congestion management tool to warrant further research, modeling and analysis.

From a policy and management standpoint, the implementation of roadway pricing, along with sufficient autonomy to set toll rates, would give the Washington State Department of Transportation the capability to manage congestion and assure the traveling public that the Alaskan Way facility will always operate in a free-flow manner. While tolls may not be popular, they tend to be accepted as an efficient way to finance a portion of transportation infrastructure by connecting a portion of the cost directly to those who use the facility. Moreover, in this era of accountability in government, providers of new transportation infrastructure have a responsibility to the public to manage those resources in a socially efficient manner. The gridlock that is becoming ubiquitous on unmanaged facilities during peak times is predictably inefficient and imposes tremendous delay costs that increase the prices of goods and services and lower the quality of life for everyone.

The following applies a relatively simple and efficient methodology for modeling the AWV as a toll facility, taking into account future travel demands and users' willingness to pay for a facility that provides travel time savings and reliable commute times. It is intended to enlighten the discussion of how tolls might be used in this corridor and assess the revenue potential of implementing an optimal or economically efficient toll structure. And while the revenue forecast ranges offered are adequately precise to inform the decision process as to whether tolls make good technical and political sense, they are not purported to be sufficiently accurate to secure debt financing from the financial markets.

In considering the implementation of user fees in any corridor, it is important to keep in mind that there is a spectrum of operating objectives that can lead to a wide range of pricing strategies. Toll facilities may be operated to maximize revenue, to achieve a revenue target (perhaps linked to debt service and/or operating costs), to maximize throughput, to keep throughput under a ceiling, or to achieve economic efficiency. Economic efficiency and revenue maximization objectives may suggest varying toll rates by time of day, direction, and/or travel distance, whereas a revenue target may be achievable with a relatively simple toll structure. And just as different operating objectives suggest different toll structures, so to does the availability and quality of alternate routes. The greater the delay reduction provided by a priced facility, the more likely the traveling public will be willing to pay for this benefit.

This toll feasibility study of the Alaskan Way Viaduct section of SR-99 is divided into five main sections. Following this introduction are sections on methodology; traffic and toll revenue forecasts; toll experience in Washington State and elsewhere; the steps involved to take this work to the next level; and key findings. A bibliography and an appendix are also provided.

METHODOLOGY

The traffic forecasts for a tolled Alaskan Way Viaduct or replacement facility were developed using the Puget Sound Regional Council's (PSRC) regional travel demand model. The PSRC model is a traditional four-step travel demand model, which has undergone continuous refinement over the past two decades and is currently hosted by the EMME/2 software package. At present, the model incorporates the base year and 2030 land use forecasts from the 2030 Metropolitan Transportation Plan (MTP) adopted by the PSRC in May 2001.

The existing PSRC model was refined for application to the AWV and Trans-Lake Washington projects.[3] This version of the PSRC model was further modified to incorporate specially developed procedures, which were used to simulate and test the viability of tolling one or more Alaskan Way Viaduct replacement alternatives. The approach for toll traffic and revenue modeling described herein represents a balance between the best theoretical technical methods, which are extremely resource and time-intensive to execute, and real world constraints regarding the stage of the project, budget and schedule that dictate a more pragmatic approach. Given a specific aim to determine the range of toll revenue that might be possible to gauge if and how it makes sense to toll this particular facility — as opposed to developing resource-intensive "investment grade" toll revenue forecasts for purposes of securing financing from the bond market — this compromise approach strikes a reasonable balance. The results of this study should help to enlighten the ongoing policy discussion of user fees within the AWV corridor, which may set the stage for further refinement using a more complex methodology and commensurate cost.

The Puget Sound Regional Council (PSRC) approach to modeling tolls was developed by an outside consultant as part of a congestion pricing analysis for the 2030 MTP process. It simulates congestion pricing (tolling to manage flow) within the existing regional modeling framework. Specifically, it approximates the optimal "economically efficient" toll in such a manner that does not require significant market research regarding user demographics and preferences, and without having to re-specify the mode choice components of the model.

In order to fully understand this approach and the interpretation of the economically efficient toll, it is useful to consider the differences between various toll road operating objectives.

Toll Facility Operating Objectives

Differing operating objectives for toll facilities in the U.S. and abroad result in differing "optimal" toll rates or structures based upon the physical, technical and political characteristics of each situation. Four such recurring objectives considered in the modeling of toll facilities, which can at times be either compatible or conflicting, are:

[3] See the Travel Forecasting Model Validation Report for Base Year 1998 prepared for WSDOT by PB, February 2002

1. Throughput maximization;
2. Revenue/profit maximization;
3. Revenue target (i.e., O&M cost plus debt service coverage); and
4. Economic efficiency in terms of congestion management.

Throughput maximization refers to a traffic engineering metric for an individual facility, measured in persons or vehicles per hour. This objective has a certain political appeal when considering the pricing of excess capacity in an HOV lane, the so-called High Occupancy Toll (HOT) lane approach. In a broader sense, this objective attempts to fully utilize the capacity of a facility by serving the most travelers possible. The assumption here is that in an unpriced situation, demand exceeds capacity such that severe congestion results, causing flow to breakdown. Pricing is thus required to maximize throughput and prevent unstable flow conditions. Maximum throughput occurs at the point just prior to flow breakdown, where a marginal increase in demand disrupts traffic flow, causing it to become unstable. For multi-lane freeway facilities, maximum throughput corresponds to traffic volumes that result in speeds of approximately 45 mph. Pricing or other demand management tools must be sufficiently precise and dynamic to prevent flow breakdown under this operating objective. In practice, this operating objective may require the use of a throughput target that approaches but falls short of maximum throughput to provide a sufficient margin of error against crossing over the line into unstable flow conditions. In addition, this objective may not result in the lowest overall travel times, particularly when considering that a higher toll could improve travel times and provide more revenue to be re-invested into capacity improvements or other investments to benefit those who choose not to pay the tolls.

Revenue maximization, or **profit maximization**, which is a form of revenue maximization subject to a cost function, capitalizes on users' willingness to pay for the toll road's attributes — primarily time savings, as well as convenience, reliability/predictability, safety, etc. Tolls are set to maximize net revenue taking into account the relationship between travel time savings and willingness to pay, and only a fraction of all travelers during peak periods will choose to pay. If throughput maximization is at one end of the spectrum of toll rates and volumes, revenue maximization is at the other. The latter objective tends to result in tolls that are notably higher and facility volumes that are notably lower than throughput maximization, along with speeds that tend to be at or near free-flow (speed limit) conditions. However, these attributes lead to high rates of diversion to alternate routes, and overall network travel times will not be minimized.

The **revenue target** objective seeks to achieve a particular threshold, such as sufficient revenue to cover the toll facility's operating and maintenance costs (O&M) and ongoing debt service expenses by a reasonable margin, or alternatively to fund some other objective such as transit service in the same corridor. To the extent that the target is less than the maximum revenue attainable, this objective results in a lower toll rate, and thus higher traffic volumes than the revenue maximizing objective. Also, since debt payments are often fixed, and increasing O&M cost may be offset by growing traffic demand, this objective may be associated with toll rates that do not increase regularly with inflation.

The **economic efficiency** objective uses tolls to correct for the economic distortion or market imperfection that occurs with an unpriced highway facility, resulting in over-consumption of the roadway by users that do not fully perceive all marginal costs of their use. An individual user entering an unpriced roadway perceives only his or her own personal delay or time costs, and not the "external" impacts that his or her vehicle imposes on the traffic flow, despite the fact that this results in additional delay to other users. The latter impact on other travelers is an economic externality — a cost or benefit of a market transaction that is not reflected in the prices consumers and suppliers use to make their decisions. In this case, the market "transaction" is consumption of the road for travel, the consumer is the individual roadway user, the "price" is the individual's travel time or time cost for the road use, and the supplier is the road owner. Because a user's travel choices do not consider the incremental delay they impose on others, a negative externality results.

A price signal in the form of a toll can be used to get the user to recognize the delay they impose on others in making their own travel choices. Tolls are set to the levels that allow only those users whose benefits of travel equal or exceed the marginal costs of travel. In the short run, ignoring pricing issues for auto use, the marginal cost of vehicular travel is the sum of the private travel time cost for that vehicle plus the social delay cost it imposes on other vehicles. In other words, the efficient toll is defined as the one at which the user is paying a price that equals the true short-run marginal cost of travel. Since the user's private costs are "paid" in time, the actual monetary "efficient" toll rate for this objective is the amount that causes users to fully consider the social delay costs that their travel decisions impose on other users of the roadway.

On an uncrowded facility, the addition of another vehicle has a negligible effect on the travel time for the relatively few existing vehicles. With excess capacity, the external cost represented by the economically efficient toll is very low as delay externalities are too insignificant to matter. However, the external cost or incremental delay factor rises with volume and can become quite substantial as the facility approaches capacity, when its performance under congestion deteriorates rapidly with additional demand.

Assuming that users have perfect information about pricing, that toll revenues are used to make cost-beneficial highway investments, and that pricing is ubiquitous, then short-run marginal cost toll pricing allows the road network to operate with maximum net social benefits from the resources used to build and operate roads. In this case, the economically efficient toll rate **maximizes travel time savings**, which for a given volume of traffic, **minimizes total network travel time**.[4] In theory, toll rates resulting from the economic efficiency objective would lie somewhere between the revenue maximizing toll and the throughput maximizing toll.

In practice, this operating objective is difficult to measure and achieve, making it difficult to know where in the spectrum the estimated toll rate lies. Market imperfections, incomplete information, and less than ubiquitous tolling lead to sub-optimal behavior and increased diversion, and may result in toll rates that are higher than intended. Nonetheless, the more diversion opportunities are contained, and the more inelastic demand is (as would be the case during peak periods), the narrower the margin of error.

[4] Note that the proper measurement of total travel benefits includes the toll revenues since some of the time savings are captures by the tolling authority and returned to all users in the form of cost-beneficial highway investments.

PSRC Modeling Approach to Congestion Pricing

The PSRC approach for simulating tolls/congestion pricing within the regional travel demand modeling framework is theoretically equivalent to the fourth operating objective above, that of economic efficiency. In reaching equilibrium, the traditional four-step PSRC regional model attempts to minimize overall network travel times, subject to various constraints including an essentially fixed level of demand by analysis year. The same is true when tolls are added as an additional time cost or impedance to the network links that represent toll facilities. When demand is assumed to be relatively fixed, minimization of network travel times is equivalent to maximizing travel benefits (time savings), which is the objective of the economically efficient toll rate.

In practice, limitations of the model framework and in the assumptions for applying the economically efficient toll structure rarely yield true economic efficiency. Rather, the model estimate for the economically efficient toll rate may fall in a range between the theoretical revenue maximizing toll rate and the throughput maximizing toll rate. To the extent that tolling is more pervasive or ubiquitous, and/or diversion to alternate (unpriced) routes is minimized, the model estimate for the economically efficient toll will converge on the true value, whereas the more isolated tolling is and the more prevalent are diversion opportunities, the more likely the model estimate for the economically efficient toll will diverge from its true value and approach the revenue maximizing value.

Under the PSRC approach, roadway pricing is introduced by adding an impedance increment to travel times used in the regional model (in the form of a time cost convertible to a monetary toll) that brings the total impedance up to the level that reflects the true incremental impedance, rather than just the impedance perceived by each user. This is done by modifying the mathematical specification of the model's volume-delay function(s) to incorporate not only the "own" delay, but also the incremental delay imposed on other vehicles on a link-by-link basis.[5] The greater impedance perceived on the toll links causes diversion to non-toll links by those users for which the additional toll time cost triggers total costs to exceed the toll facility's benefits. It is important to note that overall demand does not change in response to tolls; rather, the model redistributes demand in a different manner among alternative routes.

Assessment of the Optimal Toll Time Cost

Since the PSRC regional model's volume-delay function is a function of link volume-to-capacity (V/C) ratios, given an assumption for the desired free-flow speed, the optimal toll for each link and direction — expressed as a time cost per mile — can be derived based solely on the model output V/C ratios. The marginal cost of delay equation is provided below, with Table 1 illustrating the one-to-one correspondence between selected V/C ratios and the optimal toll, as a minute per mile time cost, for a facility with an assumed free-flow speed of 50 mph. Figure 1

[5] The reader is referred to PSRC's Transportation Pricing Alternatives Study — Technical Memorandum 3: Simulating Congestion Pricing in EMME/2, which details the mathematics of the modification to the model's volume delay function.

on the following page plots the volume-delay relationships with and without consideration of the external delay costs.

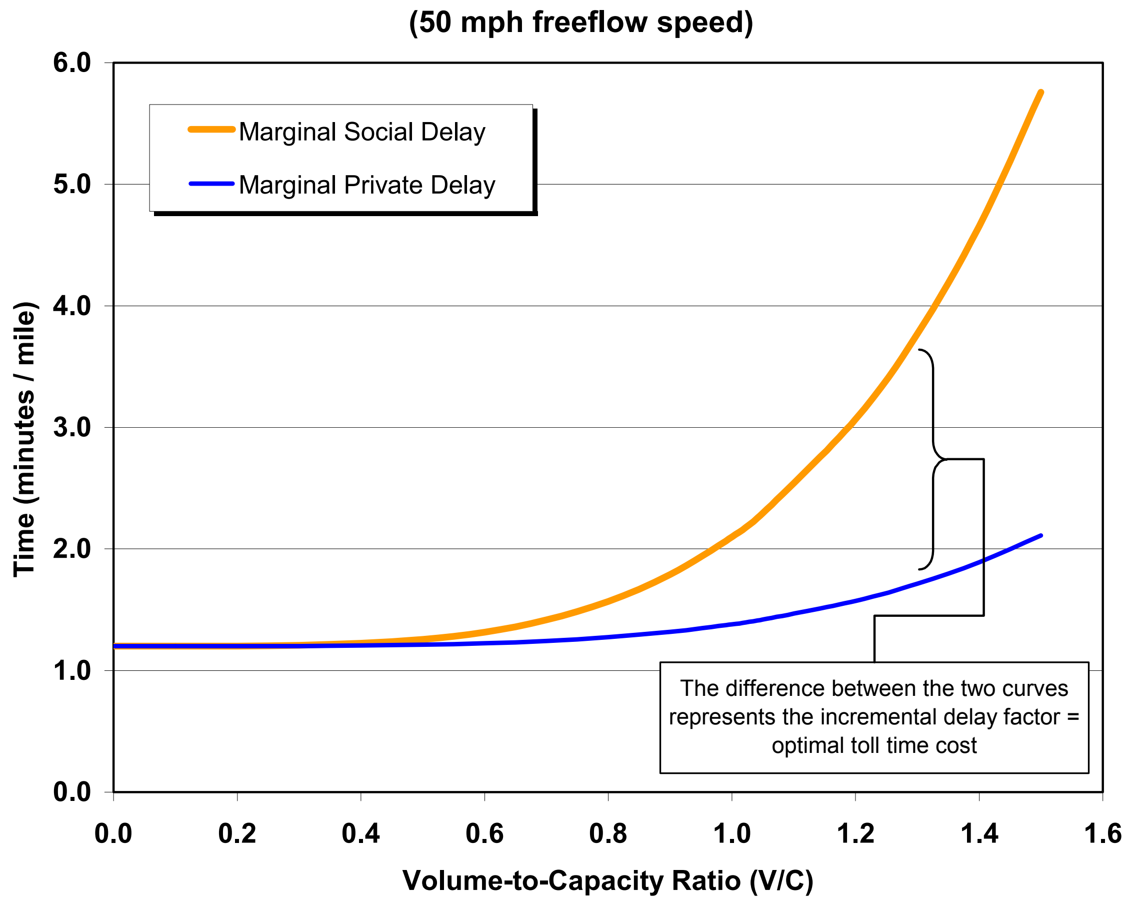
$$m(v) = \underbrace{t_0\left[1 + 0.15\left(\frac{v}{c}\right)^4\right]}_{\substack{\textit{private "own"}\\ \textit{delay cost}}} + \underbrace{\left[t_0 \cdot 0.6\left(\frac{v}{c}\right)^4\right]}_{\substack{\textit{external delay}\\ \textit{cost = toll time cost}}}$$

where $m(v)$ = marginal social cost of an additional vehicle
t_0 = free-flow time for a link distance (speed)
v = hourly traffic volume for all lanes
c = hourly capacity, all lanes

Table 1
Optimal Toll Time Costs by V/C Ratio for a 50 mph Facility

V/C Ratio (50 mph free-flow speed facility)	*Incremental Delay Factor = Optimal Toll Time Cost (minutes / mile)*	*V/C Ratio (50 mph free-flow speed facility)*	*Incremental Delay Factor = Optimal Toll Time Cost (minutes / mile)*
0.0	0.000	0.8	0.295
0.1	0.000	0.9	0.472
0.2	0.001	1.0	0.720
0.3	0.006	1.1	0.875
0.4	0.018	1.2	1.493
0.5	0.045	1.3	2.056
0.6	0.093	1.4	2.766
0.7	0.173	1.5	3.645

Figure 1
Volume-Delay Functions for "Own" and "Total" Vehicle Marginal Delay



With regard to Table 1, note that the higher the free-flow (design) speed for the facility, the lower the "optimal" economically efficient toll, all else equal. For example, at a V/C of 0.9, the optimal toll time cost for a 50 mph facility is 0.472 minutes per mile, but drops to 0.394 minutes per mile for a 60 mph facility. At first glance, this result seems counter-intuitive, based on the logic that a higher speed would generate additional time savings over alternative routes, and thus, a higher toll/greater willingness to pay by users. In a static sense, this is true, though in reality, there are several dynamic factors at work that can make the resulting toll rate go either direction. In the example above, it is assumed that the 60 mph facility has a higher capacity than the 50 mph facility.[6] At a V/C ratio of 0.9, the 60 mph facility not only moves more vehicles, but also has greater room for additional vehicles, and thus the time cost that one additional vehicle places on all other vehicles — the optimal toll time cost — is smaller.

Within the regional EMME/2 model framework, a higher free-flow speed assumption not only generates additional time savings, but also increases the hourly capacity of the facility, both of which cause the toll facility to attract new users from alternative routes. New users push

[6] The design speed in this example could also be a proxy for a facility that is replaced at a higher design standard that results in greater capacity.

volumes upward, and the optimal toll time cost rises with V/C ratios, which in turn causes diversion to other routes, and the process iterates until a new equilibrium is reached with the same overall network travel demand. The new model equilibrium may or may not result in a higher toll time cost per mile, depending on the characteristics of alternative routes, the amount of time savings provided, and the overall levels of demand and congestion in the network.

Estimating Values of Time

Since tolls within the EMME/2 modeling framework are expressed as time costs per mile, it is necessary to convert these to monetary amounts using value of time information. In this context, value of time is defined as a roadway user's willingness to pay to avoid delay, measured in dollars per hour. Value of time has been shown to be closely related to household income levels or average wage rates; in fact, there is evidence that, for commute trips, the ratio of in-vehicle travel time to the wage rate is generally constant across a wide range of income levels. The challenge lies in estimating an appropriate value of time for setting toll rates, because a person's willingness to pay to avoid delay varies by income, trip purpose, peak versus off-peak times of day, travel mode, level of traveling comfort, and even with the level of congestion, which increases travel time uncertainty.

The literature on the value of travel time is extensive and well developed; Small (1999) provides an excellent review of current research. Values of time in research studies are most often determined by conducting stated preference survey (SPS) techniques in which travelers are asked about their willingness to pay for various trade-offs regarding expected travel time and variability. Mode choice models are estimated using the SPS results and the marginal rates of substitution between the costs and travel times of alternatives choices are evaluated. Alternatively, attitudinal panel studies can be used to assess values of time and willingness to pay for delay reduction and/or travel time reliability. A panel study uses repeated surveys of the same sample of users over time to track household income, trip making and travel behavior, route choice, etc., and infers values of time based upon repetitive revealed behavior. This method is particularly useful for assessing values of time for route choices that involve an existing toll facility, and has been employed as part of a series of studies for the I-15 Congestion Pricing Project in San Diego.

In considering the application of tolls on a replacement facility for the Alaskan Way Viaduct, the necessary market research of users and resulting studies have simply not been done for this or any comparable user group in the Puget Sound Region. Given this study's objective to assist decision-makers in determining if tolling looks promising enough to warrant the considerable expense of further research, modeling and analysis, it is necessary to draw on the experience of studies in other areas to estimate values of time for AWV users. This is typically done by relating the value of time to average wage rates in other areas and then applying the resulting proportion to local wage rates.[7] The experience of other toll facilities, especially those that are

[7] In 2000, the average wage rate in King County was $23.66 as estimated from Washington State Employment Security Department data on covered employment and total wages and salaries paid.

dynamically priced adjacent to a parallel unpriced roadway (e.g., SR-91 in Orange County, California) can also provide useful information on willingness to pay.

Several studies have been undertaken to measure value of time. Supernak (2001) summarizes a review of these studies, noting the following.

> Cambridge Systematics (1977) estimated that commuters in the Los Angeles area valued in-vehicle time for non-business travel at 72 percent of their wage. MVA Consultancy (1987) estimated that the value of time of commuters in England varied between 22 and 55 percent of gross wage for high-income earners, and over 100 percent for the lowest income earners. Hensher (1989) estimates a value of time for Australian commuters at 28 percent of their gross wage. Small (1992) summarizes these and other studies, with the conclusion that a "reasonable average value of time for journey to work is 50 percent of the gross wage rate."

One of the challenges in estimating and measuring value of time is understanding what exactly it represents a willingness to pay for, as factors other than delay reduction that may be "hidden" in the value of travel time if not controlled for separately. For example, if other travel characteristics such as comfort/convenience or travel time reliability are not controlled for, then their values may be reflected in the "observed" value of time, making the measure less than ideal for comparing modes and route choices. This can be seen by the fact that congestion often increases the willingness to pay for travel time reductions — here the congestion is increasing willingness to pay to reduce uncertainty, in addition to reducing delay. This suggests that the selection of a appropriate fraction of the prevailing wage rate to serve as the value of time, when based on toll experience elsewhere, should take into account all the attributes users were paying for, which may be more than just delay reduction.

Some interesting results have come to light based upon studies of SR-91. The Cal Poly Applied Research and Development Facilities and Activities (ARDFA) transportation research group conducted a three year series of studies on the impacts of the SR-91 Variable Toll Express Lane facility that opened on December 27, 1995. Objectives included evaluating the impacts of variable-toll express lanes along SR-91 in California while also gaining insight into traveler's reactions to market-based road pricing as a solution to increasing congestion along California's highways.

- There exists a strong correlation between tolled express lane patronage and travel time savings. In spring 1997, the percentage of SR-91 travelers who used the express lanes ranged from about 7% in the mid-day off-peak, when time savings were minimal, to a high of 35% during the peak hour when delay to freeway users was an estimated 12-13 minutes. These observations imply a value of time for SR-91 commuters of $13-14 per hour. However, implied values of time across points in time vary substantially.
- Despite the correlation between travel time savings and the percentage of SR 91 traffic using the toll lanes, some toll lane users choose to use the toll lanes under traffic conditions where the expected value of their time savings is clearly less than the tolls paid. Driving comfort and the perception of greater safety were cited by travelers as the principal supplemental benefits motivating this behavior.

- Surveys conducted with SR-91 peak period travelers provide evidence that many commuters overestimated their true time savings when using the express lanes. This implies that actual values of time may be less than studies have estimated, or that users are "valuing" other travel attributes such as reliability in their travel time savings estimates.

Market research and mode choice model estimation for SR-15 in San Diego suggest a mean value of time of about $16 per hour, although it is noted that the population using this corridor is relatively affluent. In this case, the models did not separately control for travel time reliability, such that the value of "time savings" also includes the value of those unmeasured reliability improvements that generally go along with them for toll facilities.

Values of Time Assumed in the Optimal Toll Rates

Current literature generally converges on a value of time for work trips equal to 50% of average wage rates for the relevant travel market area (Small, 1999 & 1992, and Waters, 1992). It is recognized that this value primarily represents a willingness to pay for delay reduction, but may also include a willingness to pay for reducing uncertainty, improving comfort, and other attributes generally associated with toll facilities. In King County, the most recent available employment data from the Washington State Employment Security Department yields an average wage rate of $23.66 per hour for the year 2000. One-half of this amount, or $11.83, was thus established as the "base value of time" and used to generate toll rates per mile from the optimal toll time costs.

An additional "low value of time" was also established at one-third the average wage rate, or $7.89 per hour for two reasons. First, it is recognized that other previous studies in the Puget Sound region, notably the I-405 EIS effort, have assumed values of time closer to one-third the average King County wage rate. Second, a "half wage rate" value of time may include willingness-to-pay factors for other travel attributes beyond reducing delay, which may or may not vary between tolled and unpriced routes.

Since the true value of time for AWV users is yet unknown, the use of two values yields a range that likely includes the correct average value. Two time values also yields two sets of optimal toll rates, which helps to bracket the resulting revenue forecasts within a range that is more likely to include the true revenue possible. However, in this context, two sets of optimal toll rates do not allow us to test the toll elasticity of demand nor do they impact the expected traffic volumes. Rather, they merely allow us room for error in estimating users' willingness to pay for delay reduction.

Finally, considering that the replacement for the Alaskan Way will not open for several years, the value(s) of time underlying the set of optimal toll rates will need to be inflated to year-of-opening dollars to yield the correct revenue estimates.

Limitations of the Toll Modeling Approach

A key question raised by policy-makers when considering the implementation of a toll facility is how traffic and revenue will be impacted by changes in toll rates. At heart of this question is the concept of toll elasticity of demand — how travel behavior changes with varying toll rates, holding all other variables constant. Demand is said to be inelastic if a *given percentage increase* in the toll rate results in a *smaller percentage decrease* in traffic volumes. When demand is inelastic, marginal increases in the toll rate will generate additional total revenue. Conversely, when demand is elastic, the resulting percentage drop in demand is larger than the percentage increase in the toll, and overall revenue drops. Normally, the demand for any good or service is inelastic at relatively low prices, but becomes increasingly elastic as prices rise. At some price in between, revenue is maximized.

Although the methodology developed for the PSRC is intended to identify the optimal or economically efficient toll — which most likely does not vary substantially from revenue maximizing toll — it cannot tell us by *how much* demand, and thus, revenue will change at different toll rates.

Detailed market research and the specification of a toll mode choice model — both of which would be required to estimate elasticities of demand — are not part of the PSRC methodology for simulating congestion pricing within the EMME/2 modeling framework. In the event that the revenue results of this feasibility study are sufficient to warrant the further research and expense, a later section of this report discusses the steps required to take the traffic and revenue forecasts to the next level.

Moreover, the regional model may not be very adept at simulating certain types of diversion. In particular, it does not do a good job of modeling trips that would shift to less congested time periods, or perhaps be eliminated or combined with other trips. As such, it may overstate the levels of diversion to alternate routes within a given time period such as the PM peak. Further research and model refinements are needed to get a better handle on diversion and how users will alter their travel behavior when faced with toll charges for travel.

TRAFFIC AND TOLL REVENUE FORECASTS

Given that the purpose of this study is to enlighten the discussion of tolling rather than provide "investment grade" revenue forecasts, a "bookends" approach was taken to projecting toll revenue. This involved varying a number of parameters in order to draw boundaries around the likely revenue potential. Specifically, a "no-action" and a "full replacement" alternative were both modeled as toll facilities, combined with the application of two different sets of optimal toll rates calculated using the two values of time, and last, factoring with and without tolling on weekends. The resulting spectrum of revenues over time can be considered as a pair of bookends, within which the true revenue potential likely lies.

The PSRC EMME/2 travel demand forecast model's networks were prepared for the Baseline "No-Action" and Alternative D scenarios and the model was used to prepare traffic forecasts for the base year (1998) and the forecast year (2030). The model was run with the standard volume-delay function for the case without tolls in order to generate the traffic volumes from which to measure toll diversion impacts and congestion reduction. In addition, the model was run with the modified volume-delay function, which adds the additional impedance corresponding to the external delay component to simulate the case with the optimal toll in place. The corresponding volume-to-capacity (V/C) ratios are used to identify the incremental time costs that correspond to the economically efficient "optimal" toll rates per mile, and the resulting link volumes and distances are used to project toll revenue.

The following presents some general assumptions of the forecasting process, the resulting traffic forecasts, and ranges for the projected toll revenue under the Baseline "No-Action" Alternative and Alternative D.

General Assumptions

Roughly half of the AWV travelers use the facility to gain access to or from downtown, with the remainder using the facility to get through downtown to and from points further north. Given the nature of this travel combined with the methods used to model tolls, it was most appropriate to assume that tolls would be charged on a per-mile basis. In other words, users would be charged only for the distance they travel on the AWV or its successor facility rather than assuming one flat toll rate that simply buys access to the roadway. With electronic toll collection, this assumption poses no technological challenges; however, if manual tolling were to be allowed, then it still may be necessary or practical to charge cash paying customers a flat toll rate corresponding to the entire distance regardless of how far they actually travel.

The traffic and toll revenue forecasts also reflect the assumption of **100% electronic toll collection (ETC)**. This assumption was made to avoid having to model toll transaction time costs inclusive of any queuing delays at the toll plaza that might occur at peak travel times. It was recognized that although the vast majority of vehicle-trips on the AWV are made by regular users who would obtain the necessary ETC vehicle transponders, there will be some infrequent users, visitors, and even regular users who, for whatever reason, will not have transponders and who would thus be excluded from ETC.[8] To account for the relatively small number of non-revenue trips made by such users — without considering alternative payment methods or enforcement mechanisms/costs — and to allow for transit vehicles to travel at no charge, all toll revenue forecasts were reduced by 10%. It is likely that this revenue adjustment more than compensates for the revenue loss of 100% ETC.

If a manual toll payment method were provided, then the aforementioned downward toll revenue adjustment would not be required (excepting a small component for transit vehicles), but the underlying facility demand may also be diminished to the extent that one or more toll plazas add to overall travel times. Similarly, operating and maintenance costs would rise to account for the additional labor and toll plaza facilities required. Moreover, ETC vehicle transponder participation would likely be much lower for infrequent and moderate users than if no cash payments were accepted.

Additional traffic modeling and toll revenue forecasting assumptions follow below. These assumptions are made for purposes of identifying a range of potential revenues, and in no way reflect any official decisions regarding the replacement alternatives.

- The **Baseline "No-Action" Alternative** reflects the existing Alaskan Way Viaduct 's physical characteristics, including lane widths, capacity, 50 mph speed limit, and access points. The toll portion is 4.02 miles from the SR-99 interchange with Spokane Street in the south to the Battery Street Tunnel portal in the north at Denny Way.
- **Alternative D** was modeled as representative of a "maximum construction" replacement facility at the opposite end of the scale from no-action. The alignment stretches 4.93 miles from Spokane Street in the south to Roy Street in the north. Physically, it reflects a cut and cover tunnel for both directions between a portal at Roy Street and a portal at Royal Brougham / SR-519, with various midtown access points in between. More importantly, Alternative D represents a replacement facility with the same number of lanes per direction as the existing facility, but constructed to current design standards in terms of lane widths, geometry and access ramps. These factors allow for marginal increases in speeds and capacities relative to the existing AWV.
- The **forecast horizon** is **2030**, with **2009** the assumed **year of opening** for the new facility. Forecast results between the base year of 1998 and 2030 are used to interpolate volumes, V/C ratios, and optimal toll rates the opening year and other intermediate years.
- The **base year of 1998** employs the existing highway and transit networks (in terms of facilities, capacities and service characteristics) and applies the current origin-destination trip matrix based upon existing land use and transportation system attributes.
- The **future year** employs the 2030 highway and transit network improvements along with the future origin-destination trip matrix based upon the production and attraction

[8] The 407 Express Toll Route in Toronto, Canada is 100% ETC but allows for autos without transponders to be charged tolls via automatic license plate recognition. A bill is sent to the registered vehicle owner for the toll amount (on a per kilometer basis), along with an administrative charge of approximately $1.75 US.

patterns resulting from future population, employment and land use projections within the region. The 2030 highway network included all committed and funded regional projects in the PSRC, WSDOT and local Transportation Improvement Plans. The 2030 transit network includes present service changes since 1998 along with transit operators' six-year plan service improvements through 2007, with transit service assumed to increase at one percent per year thereafter through 2030. In addition, the future transit network assumes the Sound Transit LRT line from SeaTac to Northgate as well as other services in Phase 1 of the Sound Move Plan.

- As previously described, the **value of time** is computed as either one-third (low) or one-half (base) of the annual wage rate for King County, which was $23.66 in the year 2000.
- Three **weekday toll time periods** were modeled — a three hour AM peak period (6AM – 9AM); a four hour PM peak period (3PM – 7PM); and an eight-hour off-peak period composed of six midday hours (9AM – 3 PM) and two evening hours (7PM – 9 PM).
- Three **weekday toll rates** were applied — a peak period, peak direction rate; a peak period, reverse or non-peak direction rate, and a midday rate applied to both directions.
- The **weekend toll time period** was modeled as the 15 hours corresponding to the majority of travel applying the weekday midday toll rate and assuming one-half of the weekday travel demand per weekend day.
- **Optimal toll rates** were computed based upon the V/C ratio for each model link or segment of the project alternatives, and the overall toll rates assigned to each alternative by time period and direction were computed as weighted averages of each link's rate.
- **Time of day traffic distributions and vehicle class shares** were taken from a separate Parsons Brinckerhoff study of truck traffic on the AWV. In accordance with industry practice, **truck toll rates** were assumed to be a multiplier of the auto toll, ranging from 2× to 4× based upon the number of axles (2, 3, and 4+). Truck data for the AWV suggests an average multiplier of 3× be applied to 3.7% of the traffic volume occurring during the 15-hour toll time period.

Baseline "No-Action" Alternative Traffic Projections

Traffic volumes were modeled with and without optimal tolls for all daily time periods. Table A- 3 in the Appendix provides the resulting annual average daily traffic volumes, toll diversion rates, and time period V/C ratios, by model link, for 1998, 2009, and 2030. The model suggests that tolls, if implemented today, would cause approximately 12.6% of AWV daily vehicle trips to divert to alternative routes, with the daily rate of diversion growing to nearly 14% by 2009, the assumed year of opening. By 2030, the model predicts toll route diversion of 16.4% of the unpriced demand. Diversion rates during certain peak times of the day could reach 20%. As overall demand grows, the economically efficient or optimal toll rate would rise to cause a higher rate of diversion necessary to maintain uncongested traffic flow conditions.

Optimal toll rates were then derived from the with-toll modeled traffic volumes and V/C ratios by model link and time period for 1998 and 2030. Table 2 presents these rates — expressed as VMT weighted averages and converted to monetary units per mile in year 2000 dollars — for various time periods and travel directions, under both the low value of time of $7.89 per hour and the base value of time of $11.83 per hour. Optimal toll rates for night-time hours proved to be insignificant due to low demand levels and were consequently set to zero.

Table 2
Average Optimal Toll Rates for the Baseline Alternative (2000 Dollars)

Toll Rates per Mile — Baseline	Base Value of Time		Low Value of Time	
	1998	2030	1998	2030
Off-Peak (Midday) Toll Rate	$0.03	$0.03	$0.02	$0.02
Peak Period/Peak Direction Toll Rate	$0.11	$0.14	$0.07	$0.09
Peak Period/Reverse Direction Toll Rate	$0.04	$0.06	$0.02	$0.04
Night Toll Rate	$0.00	$0.00	$0.00	$0.00

Note that the optimal toll rates in year of collection dollars should increase over time for two reasons:

1. **Growth in traffic demand will necessitate an increasingly higher optimal toll in order to elicit the appropriate travel behavior and diversion to maintain an economically efficient traffic flow; and**

2. **Over time, general inflation will increase the average wage rate, and thus the value of time, the latter of which drives the calculation of the optimal toll rate.**

The results herein assume that the posted toll rates per mile are maintained at their optimal toll levels through annual increases for both inflation as well as rising demand. Clearly, the operating objectives of the toll facility and the flexibility to manage toll rates to prevent congestion — including annual increases that could exceed general inflation — will require education of the decision-makers and implementation of appropriate policies.

A restricted toll structure or a flat-rate toll poses a downside risk that the operative tolls become sub-optimal to the point they no longer manage congestion. The occurrence of congestion on the AWV replacement facility would likely reduce person-throughput, network efficiency, and negate part of the reason why tolls are imposed in the first place.

Taking into account the implementation of tolling only after a new facility could be completed (no sooner than 2009), Table 3 presents the proposed toll rate schedule for the Baseline "No-Action" Alternative using the base value of time of $11.83 per hour. Note that values of time and toll rates by year are expressed in both real terms (denominated by constant year 2000 dollars), and more importantly for revenue purposes, in inflated (year of collection) dollars.[9] Table A- 1 in the Appendix presents this same toll rate schedule for the low value of time of $7.89 per hour.

[9] Inflated amounts were estimated using the February 2002 projections for the Implicit Price Deflator for Personal Consumption index prepared by the Washington State Office of Financial Management and Department of Transportation.

Table 3
Toll Rate per Mile Schedule — Baseline "No-Action" Alternative
(Constant and Inflated Dollars — Base Value of Time)

Year	Constant Year 2000 Dollars				Inflated (Year of Expenditure) Dollars			
	Base Value of Time ($ / hr)	Peak Periods / Peak Direction	Peak Periods / Reverse Direction	Midday/ Evening & Weekend Both Dir	Base Value of Time ($ / hr)	Peak Periods / Peak Direction	Peak Periods / Reverse Direction	Midday & Weekend Both Directions
1998	$11.83	$0.11	$0.04	$0.03	$11.34	$0.10	$0.04	$0.03
1999	$11.83	$0.11	$0.04	$0.03	$11.53	$0.11	$0.04	$0.03
2000	$11.83	$0.11	$0.04	$0.03	$11.83	$0.11	$0.04	$0.03
2001	$11.83	$0.11	$0.04	$0.03	$12.05	$0.11	$0.04	$0.03
2002	$11.83	$0.11	$0.04	$0.03	$12.17	$0.12	$0.04	$0.04
2003	$11.83	$0.11	$0.04	$0.03	$12.43	$0.12	$0.04	$0.04
2004	$11.83	$0.11	$0.04	$0.03	$12.72	$0.12	$0.04	$0.04
2005	$11.83	$0.11	$0.04	$0.03	$13.00	$0.13	$0.05	$0.04
2006	$11.83	$0.12	$0.04	$0.03	$13.29	$0.13	$0.05	$0.04
2007	$11.83	$0.12	$0.04	$0.03	$13.59	$0.13	$0.05	$0.04
2008	$11.83	$0.12	$0.04	$0.03	$13.89	$0.14	$0.05	$0.04
2009	$11.83	$0.12	$0.04	$0.03	$14.20	$0.14	$0.05	$0.04
2010	$11.83	$0.12	$0.05	$0.03	$14.53	$0.15	$0.06	$0.04
2011	$11.83	$0.12	$0.05	$0.03	$14.89	$0.15	$0.06	$0.04
2012	$11.83	$0.12	$0.05	$0.03	$15.30	$0.16	$0.06	$0.04
2013	$11.83	$0.12	$0.05	$0.03	$15.74	$0.16	$0.06	$0.05
2014	$11.83	$0.12	$0.05	$0.03	$16.18	$0.17	$0.07	$0.05
2015	$11.83	$0.12	$0.05	$0.03	$16.65	$0.17	$0.07	$0.05
2016	$11.83	$0.12	$0.05	$0.03	$17.14	$0.18	$0.07	$0.05
2017	$11.83	$0.13	$0.05	$0.03	$17.66	$0.19	$0.08	$0.05
2018	$11.83	$0.13	$0.05	$0.03	$18.25	$0.20	$0.08	$0.05
2019	$11.83	$0.13	$0.05	$0.03	$18.89	$0.20	$0.08	$0.05
2020	$11.83	$0.13	$0.05	$0.03	$19.61	$0.21	$0.09	$0.06
2021	$11.83	$0.13	$0.05	$0.03	$20.09	$0.22	$0.09	$0.06
2022	$11.83	$0.13	$0.06	$0.03	$20.58	$0.23	$0.10	$0.06
2023	$11.83	$0.13	$0.06	$0.03	$21.10	$0.23	$0.10	$0.06
2024	$11.83	$0.13	$0.06	$0.03	$21.64	$0.24	$0.11	$0.06
2025	$11.83	$0.13	$0.06	$0.03	$22.19	$0.25	$0.11	$0.06
2026	$11.83	$0.13	$0.06	$0.03	$22.76	$0.26	$0.12	$0.07
2027	$11.83	$0.14	$0.06	$0.03	$23.36	$0.27	$0.12	$0.07
2028	$11.83	$0.14	$0.06	$0.03	$23.98	$0.28	$0.13	$0.07
2029	$11.83	$0.14	$0.06	$0.03	$24.63	$0.29	$0.13	$0.07
2030	$11.83	$0.14	$0.06	$0.03	$25.29	$0.30	$0.14	$0.07

Note: Toll operations not expected to commence prior to 2009

It is interesting to note that the optimal toll rate for the non-peak or reverse direction during the peak period increases by a larger percentage over time than does the peak period, peak direction toll. The model predicts that higher peak period, peak direction V/C ratios — compared to the peak period, reverse direction V/C ratios — leave less room for demand to grow over time. In addition, much of the peak direction travel is to/from downtown Seattle. The PSRC's regional model assumes that there will be substantial increases in the real (net of inflation) cost of parking in downtown over time, which severely limits growth in vehicle trips to/from downtown. On the other hand, in the reverse/non-peak direction, lower V/C ratios or greater excess capacity currently prevail, demand is less likely to be influenced by rising real parking costs, and thus, higher future traffic growth is possible. This, in turn, leads to more sizeable increases in V/C ratios and optimal toll rates.

Table 4 presents the forecasted weekday and weekend traffic demand from 2009 through 2030, expressed as vehicle miles traveled (VMT). Daily VMT by year is shown for each direction, and is divided between the total daily amount and that which falls during the 15-hour toll period. Approximately 86% of weekday travel, and 77% of weekend travel would be subject to tolls. Table A- 5 in the Appendix provides additional VMT demand information further divided by the three weekday toll time periods (AM peak, midday and PM peak) as well as night hours.

Table 4
Total & Toll Period Daily Vehicle-Miles Traveled — Baseline Alternative

Before ETC Non-Participation / Evasion Adjustments

Year	Weekday (24 hr) NB	Weekday (24 hr) SB	Weekday Tolled (15 hr) NB	Weekday Tolled (15 hr) SB	Weekend (24 hr) NB	Weekend (24 hr) SB	Weekend Tolled (15 hr) NB	Weekend Tolled (15 hr) SB
	100.0%	100.0%	86.2%	85.9%	100.0%	100.0%	77.1%	77.1%
2009	168,523	175,398	145,192	150,620	84,261	87,699	64,979	67,630
2010	169,185	176,091	145,743	151,201	84,592	88,046	65,234	67,898
2011	169,850	176,788	146,296	151,785	84,925	88,394	65,491	68,166
2012	170,518	177,488	146,852	152,372	85,259	88,744	65,749	68,436
2013	171,189	178,192	147,411	152,961	85,595	89,096	66,007	68,707
2014	171,864	178,898	147,972	153,553	85,932	89,449	66,268	68,980
2015	172,542	179,608	148,537	154,148	86,271	89,804	66,529	69,254
2016	173,223	180,321	149,104	154,746	86,612	90,161	66,792	69,529
2017	173,908	181,037	149,673	155,346	86,954	90,519	67,056	69,805
2018	174,596	181,757	150,246	155,949	87,298	90,879	67,321	70,082
2019	175,288	182,480	150,822	156,555	87,644	91,240	67,588	70,361
2020	175,983	183,207	151,400	157,164	87,991	91,603	67,856	70,641
2021	176,681	183,937	151,981	157,776	88,340	91,968	68,125	70,923
2022	177,382	184,670	152,565	158,390	88,691	92,335	68,395	71,205
2023	178,088	185,406	153,152	159,008	89,044	92,703	68,667	71,489
2024	178,796	186,146	153,742	159,628	89,398	93,073	68,941	71,775
2025	179,508	186,890	154,334	160,251	89,754	93,445	69,215	72,061
2026	180,224	187,637	154,930	160,877	90,112	93,818	69,491	72,349
2027	180,943	188,387	155,529	161,506	90,471	94,194	69,768	72,639
2028	181,666	189,141	156,130	162,138	90,833	94,571	70,047	72,929
2029	182,392	189,899	156,735	162,773	91,196	94,949	70,327	73,221
2030	183,122	190,660	157,342	163,411	91,561	95,330	70,608	73,515

Note: Toll operations not expected to commence prior to 2009

Baseline "No-Action" Alternative Toll Revenue Forecasts

With the traffic forecasts converted to weekday and weekend daily VMT by the various toll time periods, the optimal toll rates can be readily applied to generate daily and annual revenue forecasts. A range of revenue that might be possible under the Baseline "No Action" Alternative was considered by varying the value of time underlying the optimal toll rate as well as excluding weekend toll revenues. The low end of the range employs the low value of time and excludes weekend toll revenue while the high end of the range applies the base value of time and adds in weekend revenue. Given the nature of the forecasting methods and the lack of in-depth market research, a concerted effort was made to avoid producing forecast scenarios that might be considered optimistic.

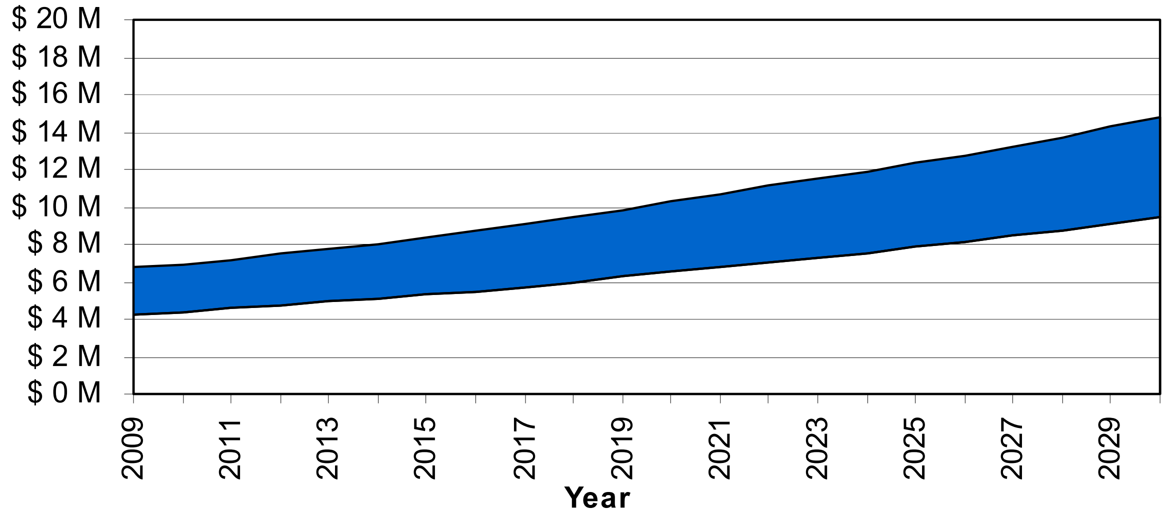
Initial revenue estimates calculated from the daily VMT data by toll period were adjusted upward to reflect the percentage of the traffic representing trucks paying higher tolls and adjusted downward to account for ETC violators, evasion or vehicle transponder non-participation and transit exemptions. Weekday and weekend/holiday daily revenue estimates were then annualized using appropriate factors. The resulting annual toll revenue forecast ranges for the Baseline Alternative in constant and inflated dollars are presented in Table 5. Figure 2 graphically presents the likely range of revenue in inflated or year of collection dollars.

Additional detailed revenue information for the Baseline Alternative can be found in Appendix Table A- 7 expressed in constant dollars, and in Table A- 8 expressed in inflated (year of collection) dollars.

Table 5
Annual Toll Revenue Ranges — Baseline "No Action" Alternative

Year	Constant Year 2000 Dollars		Inflated (Year of Collection) Dollars	
	Low Time Value No Weekend Tolls	Base Time Value Weekend Tolls	Low Time Value No Weekend Tolls	Base Time Value Weekend Tolls
2009	$ 3.5 M	$ 5.6 M	$ 4.3 M	$ 6.7 M
2010	$ 3.6 M	$ 5.7 M	$ 4.4 M	$ 7.0 M
2011	$ 3.6 M	$ 5.7 M	$ 4.6 M	$ 7.2 M
2012	$ 3.7 M	$ 5.8 M	$ 4.7 M	$ 7.5 M
2013	$ 3.7 M	$ 5.8 M	$ 4.9 M	$ 7.8 M
2014	$ 3.7 M	$ 5.9 M	$ 5.1 M	$ 8.1 M
2015	$ 3.8 M	$ 5.9 M	$ 5.3 M	$ 8.4 M
2016	$ 3.8 M	$ 6.0 M	$ 5.5 M	$ 8.7 M
2017	$ 3.8 M	$ 6.1 M	$ 5.7 M	$ 9.1 M
2018	$ 3.9 M	$ 6.1 M	$ 6.0 M	$ 9.4 M
2019	$ 3.9 M	$ 6.2 M	$ 6.3 M	$ 9.9 M
2020	$ 4.0 M	$ 6.2 M	$ 6.6 M	$ 10.4 M
2021	$ 4.0 M	$ 6.3 M	$ 6.8 M	$ 10.7 M
2022	$ 4.1 M	$ 6.4 M	$ 7.0 M	$ 11.1 M
2023	$ 4.1 M	$ 6.4 M	$ 7.3 M	$ 11.5 M
2024	$ 4.1 M	$ 6.5 M	$ 7.6 M	$ 11.9 M
2025	$ 4.2 M	$ 6.6 M	$ 7.8 M	$ 12.3 M
2026	$ 4.2 M	$ 6.6 M	$ 8.1 M	$ 12.8 M
2027	$ 4.3 M	$ 6.7 M	$ 8.4 M	$ 13.3 M
2028	$ 4.3 M	$ 6.8 M	$ 8.8 M	$ 13.8 M
2029	$ 4.4 M	$ 6.9 M	$ 9.1 M	$ 14.3 M
2030	$ 4.4 M	$ 6.9 M	$ 9.4 M	$ 14.8 M

Figure 2
Baseline Alternative Toll Revenue Range in Inflated Dollars



A discussion of the capital investment "purchasing power" of this revenue stream follows the presentation of the traffic and revenue projections for Alternative D.

Alternative D Traffic Projections

In contrast to the revenue projections prepared for the Baseline "No-Action" Alternative, which represent the tolling of the existing AWV, those for Alternative D consider the tolling of the most comprehensive of the "build" replacement alternatives. Revenue projections for the other build alternatives, to the extent that they offer similar access, would likely fall somewhere between those for the Baseline Alternative and Alternative D.

Alternative D represents a grade-separated replacement to the AWV comprised primarily of a cut and cover tunnel, and would differ from what exists today in the following ways:

- It would provide improved access to mid-downtown Seattle.
- Although it would include the same number of lanes, it would be designed to current, higher standards, facilitating smoother operation at slightly higher speeds, and as a result, provides a slightly higher vehicle capacity.
- It would extend the facility length by nine-tenths of a mile, adding about 23% to the current facility's 4.02 miles within the defined project area.

Traffic volumes were modeled for Alternative D with and without optimal tolls for all daily time periods for the future year of 2030. An assignment was then run using the base year model to simulate only the Alternative D network improvements in the present so as to have two points from which to interpolate intermediate years. Table A- 4 in the Appendix provides the resulting annual average daily traffic volumes, toll diversion rates, and time period V/C ratios, by model link, for 1998, 2009, and 2030. Toll diversion rates are slightly higher for Alternative D than for the Baseline Alternative.

Optimal toll rates were then estimated from the without toll traffic volumes and V/C ratios by time period for 1998 and 2030. Table 6 presents these rates — expressed as the monetary amount per mile in year 2000 dollars — for various time periods and travel directions, under both the low value of time of $7.89 per hour and the base value of time of $11.83 per hour. Once again, optimal toll rates for night-time hours proved to be insignificant due to low demand levels and were consequently set to zero.

Table 6
Average Optimal Toll Rates for Alternative D (2000 Dollars)

Toll Rates per Mile — Alt. D	Base Value of Time		Low Value of Time	
	1998	2030	1998	2030
Off-Peak (Midday) Toll Rate	$0.03	$0.04	$0.02	$0.02
Peak Period/Peak Direction Toll Rate	$0.10	$0.12	$0.06	$0.08
Peak Period/Reverse Direction Toll Rate	$0.03	$0.07	$0.02	$0.05
Night Toll Rate	$0.00	$0.00	$0.00	$0.00

Note that the optimal toll rates for Alternative D are in several cases marginally lower than those for the Baseline Alternative shown in Table 2. Several attributes that were coded into the model for Alternative D contribute to this somewhat interesting result. First, the higher design standards allow for slightly higher operating speeds. This is complemented by better connections at the north and south endpoints, and thus, reduced bottlenecks. Both of these factors lead to marginal increases in capacity, which lowers the modeled V/C ratios via the denominator, pushing optimal toll rates downward. In reaching equilibrium, the model also takes into account that slightly higher speeds and capacities will attract additional users, potentially increasing V/C ratios via the numerator, pushing optimal toll rates upward. However, because Alternative D has the slight disincentive of a longer travel distance than the existing facility, the resulting increase in users is not fully commensurate with the improvement in operating conditions (greater capacity and speed). In fact, although Alternative D attracts more users, its longer travel distance offsets its higher average operating speed, such that there are essentially no time savings, and potentially a small time cost, compared with the No-Action Alternative. All of these factors contribute to slightly lower V/C ratios for Alternative D as modeled, and in accordance with Figure 1 and Table 1, lower V/C ratios result in lower optimal toll rates.

Once again, the following revenue projections assume that the posted toll rates per mile are maintained at their optimal toll levels through both annual increases for inflation (affecting value of time) and rising demand (affecting the V/C ratio). Failure to increase toll rates to maintain optimality for either of these two effects could lead to the occurrence of congestion on the AWV replacement facility, which will reduce throughput and negate part of the reason why tolls are imposed in the first place.

Taking into account the implementation of tolling only after a new facility is completed (no sooner than 2009), Table 7 presents the proposed toll rate schedule for Alternative D using the base value of time of $11.83 per hour. As before, values of time and toll rates by year are expressed in both real terms (denominated by constant year 2000 dollars), as well as in inflated (year of collection) dollars for purposes of estimating revenue. Table A- 2 in the Appendix presents this same toll rate schedule for the low value of time of $7.89 per hour.

Alternative D exhibits more substantial growth in the peak period, reverse direction toll rate than for the peak direction toll rate for the same reasons as the Baseline Alternative.

Table 7
Toll Rate per Mile Schedule — Alternative D
(Constant and Inflated Dollars — Base Value of Time)

Year	Constant Year 2000 Dollars				Inflated (Year of Expenditure) Dollars			
	Base Value of Time ($ / hr)	Peak Periods / Peak Direction	Peak Periods / Reverse Direction	Midday/ Evening & Weekend Both Dir	Base Value of Time ($ / hr)	Peak Periods / Peak Direction	Peak Periods / Reverse Direction	Midday & Weekend Both Directions
1998	$11.83	$0.10	$0.03	$0.03	$11.34	$0.09	$0.03	$0.03
1999	$11.83	$0.10	$0.03	$0.03	$11.53	$0.10	$0.03	$0.03
2000	$11.83	$0.10	$0.04	$0.03	$11.83	$0.10	$0.04	$0.03
2001	$11.83	$0.10	$0.04	$0.03	$12.05	$0.10	$0.04	$0.03
2002	$11.83	$0.10	$0.04	$0.03	$12.17	$0.10	$0.04	$0.03
2003	$11.83	$0.10	$0.04	$0.03	$12.43	$0.10	$0.04	$0.03
2004	$11.83	$0.10	$0.04	$0.03	$12.72	$0.11	$0.04	$0.03
2005	$11.83	$0.10	$0.04	$0.03	$13.00	$0.11	$0.04	$0.03
2006	$11.83	$0.10	$0.04	$0.03	$13.29	$0.11	$0.05	$0.03
2007	$11.83	$0.10	$0.04	$0.03	$13.59	$0.12	$0.05	$0.03
2008	$11.83	$0.10	$0.04	$0.03	$13.89	$0.12	$0.05	$0.04
2009	$11.83	$0.10	$0.04	$0.03	$14.20	$0.12	$0.05	$0.04
2010	$11.83	$0.10	$0.04	$0.03	$14.53	$0.13	$0.05	$0.04
2011	$11.83	$0.10	$0.05	$0.03	$14.89	$0.13	$0.06	$0.04
2012	$11.83	$0.10	$0.05	$0.03	$15.30	$0.14	$0.06	$0.04
2013	$11.83	$0.11	$0.05	$0.03	$15.74	$0.14	$0.06	$0.04
2014	$11.83	$0.11	$0.05	$0.03	$16.18	$0.15	$0.07	$0.04
2015	$11.83	$0.11	$0.05	$0.03	$16.65	$0.15	$0.07	$0.04
2016	$11.83	$0.11	$0.05	$0.03	$17.14	$0.16	$0.07	$0.05
2017	$11.83	$0.11	$0.05	$0.03	$17.66	$0.16	$0.08	$0.05
2018	$11.83	$0.11	$0.05	$0.03	$18.25	$0.17	$0.08	$0.05
2019	$11.83	$0.11	$0.05	$0.03	$18.89	$0.17	$0.09	$0.05
2020	$11.83	$0.11	$0.06	$0.03	$19.61	$0.18	$0.09	$0.05
2021	$11.83	$0.11	$0.06	$0.03	$20.09	$0.19	$0.10	$0.06
2022	$11.83	$0.11	$0.06	$0.03	$20.58	$0.19	$0.10	$0.06
2023	$11.83	$0.11	$0.06	$0.03	$21.10	$0.20	$0.11	$0.06
2024	$11.83	$0.11	$0.06	$0.03	$21.64	$0.21	$0.11	$0.06
2025	$11.83	$0.11	$0.06	$0.03	$22.19	$0.21	$0.12	$0.06
2026	$11.83	$0.11	$0.06	$0.03	$22.76	$0.22	$0.12	$0.07
2027	$11.83	$0.11	$0.07	$0.03	$23.36	$0.23	$0.13	$0.07
2028	$11.83	$0.11	$0.07	$0.03	$23.98	$0.23	$0.14	$0.07
2029	$11.83	$0.12	$0.07	$0.03	$24.63	$0.24	$0.14	$0.07
2030	$11.83	$0.12	$0.07	$0.04	$25.29	$0.25	$0.15	$0.08

Note: Toll operations not expected to commence prior to 2009

Table 8 presents the forecasted weekday and weekend traffic demand from the opening year through 2030, expressed as vehicle miles traveled (VMT). Daily VMT by year is shown for each direction, along with the subset of VMT that falls within the toll period. Note that with tolls applied for 15 hours per day, approximately 86% of weekday travel, and 77% of weekend travel would be subject to tolls.

In contrast to the Baseline, Alternative D shows 30% more VMT during the weekday tolling period. This is due to its slightly higher volumes attributable to the aforementioned access and operations improvements, and the 23% longer travel distance within the project area.

Table 8
Total & Tolled Daily Vehicle-Miles Traveled — Alternative D

Before ETC Non-Participation / Evasion Adjustments

Year	Weekday (24 hr) NB	Weekday (24 hr) SB	Weekday Tolled (15 hr) NB	Weekday Tolled (15 hr) SB	Weekend (24 hr) NB	Weekend (24 hr) SB	Weekend Tolled (15 hr) NB	Weekend Tolled (15 hr) SB
	100.0%	100.0%	85.7%	85.7%	100.0%	100.0%	77.1%	77.1%
2009	220,643	225,425	189,173	193,246	110,322	112,712	85,076	86,920
2010	221,778	226,416	190,079	194,070	110,889	113,208	85,514	87,302
2011	222,920	227,412	190,990	194,899	111,460	113,706	85,954	87,686
2012	224,068	228,413	191,906	195,732	112,034	114,206	86,397	88,072
2013	225,223	229,419	192,828	196,570	112,611	114,710	86,842	88,460
2014	226,385	230,431	193,754	197,412	113,193	115,215	87,290	88,850
2015	227,554	231,448	194,686	198,258	113,777	115,724	87,741	89,242
2016	228,730	232,470	195,623	199,108	114,365	116,235	88,194	89,636
2017	229,913	233,497	196,566	199,963	114,957	116,748	88,650	90,032
2018	231,103	234,529	197,513	200,822	115,552	117,265	89,109	90,430
2019	232,301	235,567	198,466	201,686	116,150	117,784	89,571	90,830
2020	233,505	236,610	199,425	202,554	116,753	118,305	90,035	91,233
2021	234,717	237,659	200,389	203,427	117,358	118,830	90,503	91,637
2022	235,936	238,713	201,358	204,304	117,968	119,357	90,973	92,044
2023	237,162	239,773	202,333	205,186	118,581	119,886	91,445	92,452
2024	238,396	240,838	203,314	206,072	119,198	120,419	91,921	92,863
2025	239,637	241,909	204,300	206,963	119,819	120,954	92,400	93,276
2026	240,886	242,985	205,292	207,859	120,443	121,492	92,881	93,691
2027	242,142	244,066	206,289	208,759	121,071	122,033	93,366	94,108
2028	243,406	245,154	207,293	209,664	121,703	122,577	93,853	94,527
2029	244,677	246,247	208,301	210,574	122,339	123,123	94,343	94,948
2030	245,956	247,346	209,316	211,488	122,978	123,673	94,836	95,372

Note: Toll operations not expected to commence prior to 2009

Appendix Table A- 6 provides additional VMT demand information for Alternative D further divided by the three weekday toll time periods (AM peak, midday and PM peak) as well as night hours.

Alternative D Toll Revenue Forecasts

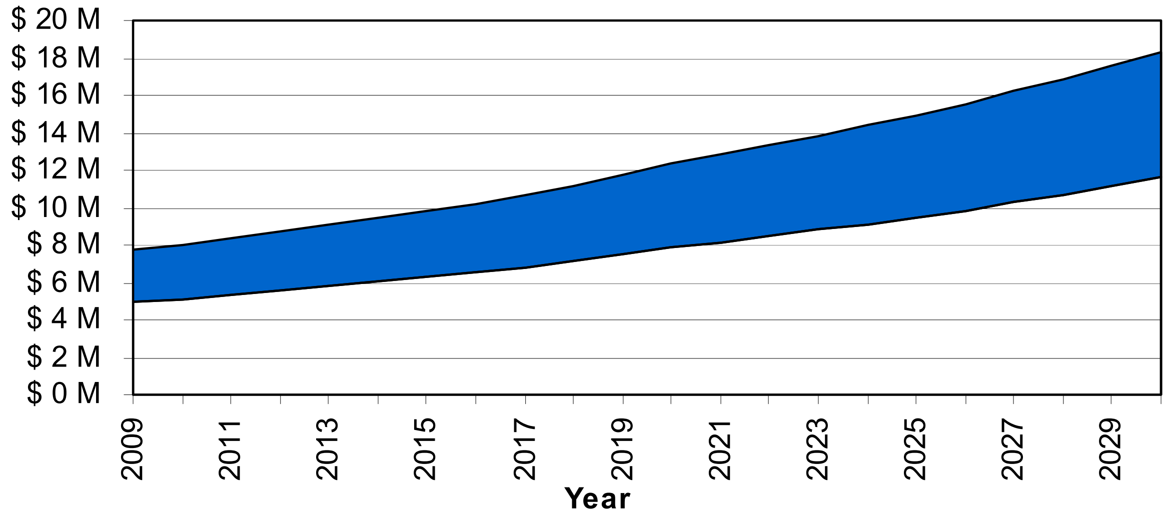
As with the Baseline Alternative, Alternative D's optimal toll rates can be readily applied to the VMT-based traffic forecasts to generate daily and annual revenue forecasts. A range of revenue was again considered by varying the value of time underlying the optimal toll rate as well as excluding weekend toll revenues. The low end of the range employs the low value of time and excludes weekend toll revenue while the high end of the range applies the base value of time and adds in weekend revenue.

Gross revenue estimates calculated from the daily VMT data by toll period were adjusted upward to reflect the percentage of the traffic representing trucks paying higher tolls, and also adjusted downward to account for ETC evasion and/or vehicle transponder non-participation. Weekday and weekend/holiday daily revenue estimates were then annualized using appropriate factors. The resulting annual toll revenue forecast ranges for the Baseline Alternative in constant and inflated dollars are presented in Table 9. Figure 3 graphically presents the likely range of revenue in inflated or year of collection dollars.

Table 9
Annual Toll Revenue Ranges — Alternative D

Year	Constant Year 2000 Dollars		Inflated (Year of Collection) Dollars	
	Low Time Value No Weekend Tolls	Base Time Value Weekend Tolls	Low Time Value No Weekend Tolls	Base Time Value Weekend Tolls
2009	$ 4.1 M	$ 6.5 M	$ 5.0 M	$ 7.8 M
2010	$ 4.2 M	$ 6.5 M	$ 5.1 M	$ 8.0 M
2011	$ 4.2 M	$ 6.6 M	$ 5.3 M	$ 8.3 M
2012	$ 4.3 M	$ 6.7 M	$ 5.6 M	$ 8.7 M
2013	$ 4.3 M	$ 6.8 M	$ 5.8 M	$ 9.0 M
2014	$ 4.4 M	$ 6.9 M	$ 6.0 M	$ 9.4 M
2015	$ 4.5 M	$ 7.0 M	$ 6.3 M	$ 9.8 M
2016	$ 4.5 M	$ 7.1 M	$ 6.5 M	$ 10.2 M
2017	$ 4.6 M	$ 7.2 M	$ 6.8 M	$ 10.7 M
2018	$ 4.6 M	$ 7.3 M	$ 7.1 M	$ 11.2 M
2019	$ 4.7 M	$ 7.4 M	$ 7.5 M	$ 11.7 M
2020	$ 4.7 M	$ 7.4 M	$ 7.9 M	$ 12.3 M
2021	$ 4.8 M	$ 7.6 M	$ 8.2 M	$ 12.8 M
2022	$ 4.9 M	$ 7.7 M	$ 8.5 M	$ 13.3 M
2023	$ 4.9 M	$ 7.8 M	$ 8.8 M	$ 13.8 M
2024	$ 5.0 M	$ 7.9 M	$ 9.1 M	$ 14.4 M
2025	$ 5.1 M	$ 8.0 M	$ 9.5 M	$ 15.0 M
2026	$ 5.1 M	$ 8.1 M	$ 9.9 M	$ 15.5 M
2027	$ 5.2 M	$ 8.2 M	$ 10.3 M	$ 16.2 M
2028	$ 5.3 M	$ 8.3 M	$ 10.7 M	$ 16.8 M
2029	$ 5.3 M	$ 8.4 M	$ 11.1 M	$ 17.5 M
2030	$ 5.4 M	$ 8.5 M	$ 11.6 M	$ 18.3 M

Figure 3
Alternative D Toll Revenue Range in Inflated Dollars



Additional detailed revenue information for build Alternative D can be found in Appendix Table A- 9 expressed in constant dollars, and in Table A- 10 expressed in inflated (year of collection) dollars.

Despite lower optimal toll rates per mile, higher traffic volumes over the longer travel distance yield a revenue range under Alternative D that exceeds that of the Baseline Alternative. In fact, over time, Alternative D provides more room for demand growth, reflected in V/C ratios and optimal toll rates that escalate by larger percentage amounts over the forecast horizon.

Annual Toll Revenue Purchasing Power

A revenue projection raises the question of how much will the annual cash flow buy, in terms of capital investment, via bond debt financing. Several factors would influence this, including the duration of construction; prevailing interest rates; debt structure, duration and issuance costs; and required debt service coverage, among others. While a detailed financial analysis is beyond the scope of this study, it is possible to gauge the approximate amount that could be leveraged through the sale of tax-exempt municipal bonds for each $1 million in toll revenues.

Under a reasonable set of assumptions based upon current market conditions, each $1 million in annual toll revenues available for debt repayment could purchase on the order of $7 to $10 million in capital investment, plus another $1 to 2 million to cover a few years of capitalized debt service during construction. Note that despite revenue growth over time, the financial markets will require that initial operating revenues available for debt service more than cover actual debt service costs, the difference being a cushion from which the debt service coverage ratio is specified. Eventually, excess revenues may be redirected to other uses, including early debt retirement.

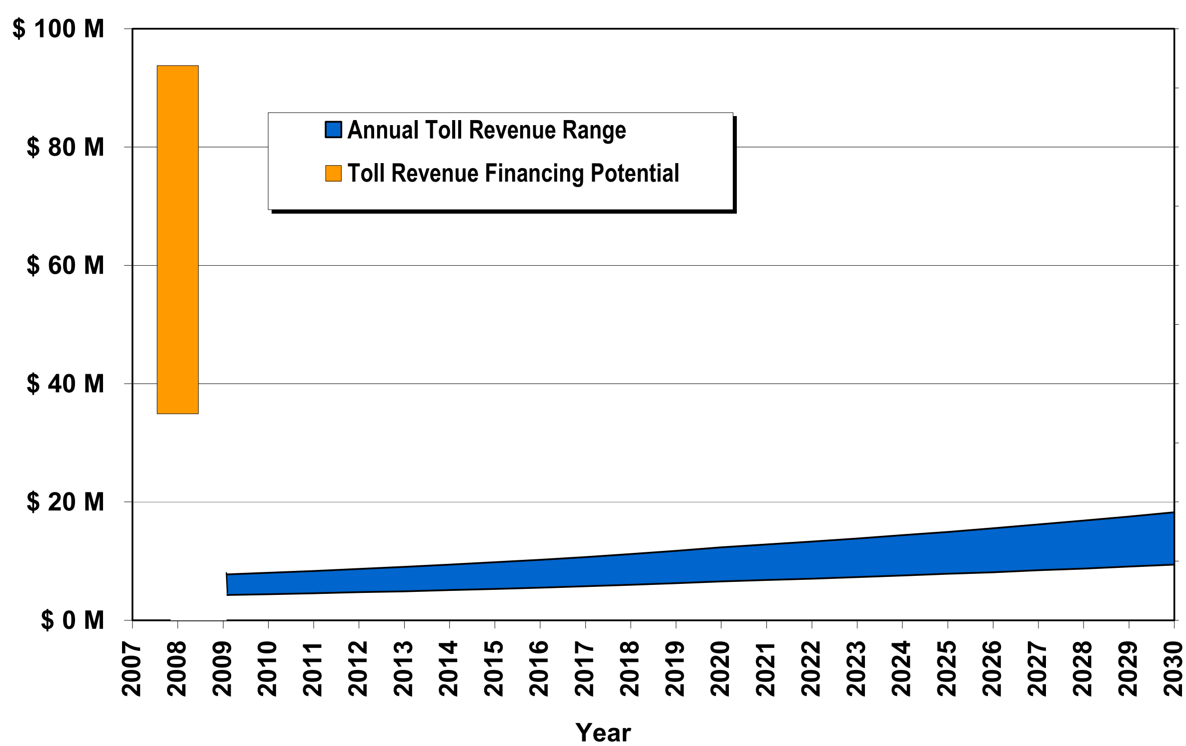
A key consideration here is that toll revenue would not be available until the new facility is opened, but borrowing will need to commence with or before construction. This in turn requires that debt service costs during construction — interest costs at a minimum, and possibly principal repayments, depending on how the debt is structured — must be capitalized as part of the construction investment cost. The delay between debt issuance and receipt of operating revenues encumbers some of the revenue stream to cover the additional project costs for debt service during construction, leaving less for pure construction activities.

For example, looking at the high end estimate of $10 million capital investment per $1 million in toll revenue, the $10 million excludes any capitalized debt service costs, which could add up to another $1.5 to $2 million. Thus, an alternative interpretation is that $1 million in toll revenues could finance upwards of $12 million in project costs, including capitalized debt service.

Assuming commencement of toll operations in 2009, the purchasing power reflected by the full range of projected revenue herein (across both alternatives) suggest a lower bound of $35 million and an upper bound of $95 million in project costs, including capitalized debt service.

Figure 4 depicts the capital investment bounds that could be financed via the overall annual revenue range. In this case, the overall annual revenue range is computed across both alternatives, the base and low values of time, and with and without weekend tolls.

Figure 4
Overall Toll Revenue Range and Project Financing Potential



TOLL EXPERIENCE IN WASHINGTON STATE AND ELSEWHERE

Though Washington State lacks recent experience with toll facilities, it is perhaps useful to examine how previous pricing influenced travel demand to help put some context to the Alaskan Way Viaduct toll demand modeling results.[10] A brief analysis of this follows.

In addition, a recent phone survey of Puget Sound area travelers conducted as part of the WSDOT Managed Lanes Study provides some insight into the public's views on tolling. Results across all respondents and trip types indicate there is strong public support for managing traffic demand to prevent congestion. For pricing as the management tool, a bit more than 40% of people indicated a willingness to pay tolls for a faster trip. When queried about tolling the I-5 Express Lanes, about 50% of respondents supported varying toll rates by time of day to manage traffic flow.

Similarly, it is illustrative to compare the proposed toll rates per mile on the AWV to other North American facilities, recognizing that each facility has unique and widely varying historical per unit construction costs and ongoing operating objectives.

Demand Effects of Removing Tolls on Washington State Toll Bridges

To put into perspective the roughly 15% toll diversion to other routes expected for the Alaskan Way Viaduct or its replacement facility, traffic data was analyzed before and after removal of tolls on the two most recent such facilities in Washington State.

Hood Canal Bridge Experience

The $2.00 toll on the Hood Canal Bridge was removed on August 29, 1985. In 1984, annual average daily traffic (AADT) was 5,982 vehicles with the toll. In 1986, AADT jumped 38% to 8,253 vehicles in the first full year without the toll. This seems to indicate that in the year before the toll was eliminated, it was causing a diversion of 27.5% of would-be vehicle trips to either be made using alternative routes, or more likely in this case, to not be made at all.

SR-520 Floating Bridge Experience

The Governor Albert Rosellini Evergreen Point Floating Bridge (SR-520) opened in August 1963 with a $0.35 toll each way. The toll rate was set to pay debt service costs for construction bonds. In today's dollars, the $0.35 toll in each direction is equivalent to $1.70. With projected inflation, this corresponds to over $2.00 in 2009, the assumed earliest year of opening for a replacement facility.

[10] WSDOT recently received approval to implement tolls on SR-16's Tacoma Narrows Bridge at an initial rate of $3.00 per round-trip. WSDOT has substantial experience charging tolls for ferry service across Puget Sound.

The SR-520 bridge toll — still at $0.35 per direction — was removed in June 1979. At the time of removal, the real cost of the toll had declined considerably since the bridge opening to about $0.85 in today's dollars, or about $1.00 in year 2009 dollars.

In 1978, the last full year of toll operations, AADT numbered 60,452 vehicles, versus 56,752 on the unpriced parallel I-90 Floating Bridge. By 1980, AADT on SR-520 had jumped 19.3% to 72,139 while traffic on I-90 fell by 7.9% to 52,283. These results suggest that toll diversion on SR-520 was approximately 16.2%, with over one-third of the toll-inhibited vehicle trips diverted to I-90, and the remainder either north around the lake or not at all.

Comparison Information for Selected North American Toll Facilities

The following provides some comparable information for selected toll facilities in U.S. and Canada for purposes of illustrating the context of implementing tolls on the AWV. While the list is by no means comprehensive, it does indicate that proposed range of toll rates for the AWV is within those found on other facilities, particularly those in California, which have similar operating objectives.

SR-91 Express Lanes, Orange County, CA

- Year Opened: 1995
- Principal operating objective: Revenue maximization
- Length, Type & Location: 10 miles, located in the median of the SR-91 freeway; extends east from the SR-91/SR-55 freeway interchange to the Riverside/Orange County line. Adjacent to free facility
- Access: end-points only
- Minimum toll segment: 10 miles
- HOV rate: 50% discount for HOV 3+
- Trucks: No
- Tolling Mechanism; 100% ETC
- Toll Unit: Entire facility distance
- Toll Range: $1.00 to $4.75 (highest tolls eastbound 4 to 6 pm)
  - AM peak: $1.90 to $3.60 (peak direction)
  - PM peak: $3.50 to $4.75 (peak direction)
- Toll Rate per Mile: $0.10 to $0.48
- Notes: Sharp directionality. Tolls vary by time of day.

I-15 FasTrak, San Diego, CA

- Year Opened: 1996

- Principal operating objective: Throughput target
- Length, Type & Location: 8 miles as a two-lane, reversible facility in the median of I-15 in San Diego, California. Barriers separate the express lanes from the adjacent free regular traffic lanes.
- Access: end-points only
- Minimum toll segment: 8 miles
- HOV rate: Free
- Trucks: No (verify)
- Tolling Mechanism: 100% ETC
- Toll Unit: Entire facility distance
- Toll Range: $0.75 to $4.00 (though escalate up to $8.00 during an incident)
  - AM peak: $0.75 to $4.00 (peak direction)
  - PM peak: $1.00 to $4.00 (peak direction)
- Toll per mile: $0.09 to $0.50
- Notes: Under severe congestion, tolls can be as high as 8.00. Toll revenues pay for operating costs and enforcement provided by the California Highway Patrol. This facility was converted from an underutilized HOV lane to a priced roadway for SOVs, and State law requires that any additional revenues be used to pay for transit. Tolls vary dynamically in relation to a published schedule.

Dulles Greenway, VA

- Year Opened: 1995
- Principal operating objective: Revenue maximization
- Length, Type & Location: Privately owned 14-mile toll road that connects Washington Dulles International Airport with Leesburg, Virginia. Provides alternate route to Route 7/28. Four lanes with reversible options.
- Access: 6 access points
- Minimum toll segment: 8 miles
- HOV rate: No
- Trucks: Yes (different rate)
- Tolling Mechanism: Credit card and ETC
- Toll Unit: flat rates charged between exits and/or plazas
- Toll Range: $0.50 to $2.00
  - Rate by distance, exits and main toll plaza
  - Lower rates on weekends

- Higher rates for 3+ axles ($1.00 to $4.00)
- Discount for Smart Tag

- Toll per mile: $0.14 (based on full length and main toll plaza)

Dulles Toll Road, VA

- Year Opened: 1984
- Principal operating objective: Revenue target?
- Length; 14 miles
- Location: The Dulles Toll Road (DTR) is an 8 lane (4 lanes in each direction) limited access highway approximately 14 miles in length, which is owned and operated by the Virginia Department of Transportation (VDOT).
- Access: 11 access/exits
- Minimum toll segment: 1 mile
- HOV rate: Free
- Trucks: Yes (different rate)
- Tolling Mechanism: 100% ETC
- Toll Unit: flat rates charged between exits and/or plazas
- Toll Range: $0.25 to $0.50
  - Extra cost per additional axle
- Toll per mile: $0.02 to $0.04

Harris County Toll Road , Houston TX

- Year Opened: 1987
- Principal operating objective: Revenue target (retirement of debt, O&M costs)
- Length, Type & Location: 83 mile tolled ring road around Houston, TX.
- Access: multiple access/exit points
- Minimum toll segment: 4 miles (based on a sample section)
- HOV rate: No
- Trucks: Yes (different rate)
- Tolling Mechanism: ETC, cash, tokens
- Toll Unit: flat rates charged between exits and/or plazas
- Toll Range: $0.25 to $1.00 ($2.00 for Ship bridge)
  - Based on distance/exit or plaza

- Extra cost per additional axle
- Discount for tokens or EZ Tag

- Toll per mile: $0.06 to $0.13 (varies by section depending on exit point)
- Notes: Sample section priced is Sam Houston Southwest

New Jersey Turnpike, NJ

- Year Opened: 1951
- Principal operating objective: Revenue target (retirement of debt, O&M costs)
- Length, Type & Location: 118 miles within the State of New Jersey, parts of which include dual tolled facilities in which trucks are prohibited on one of the two facilities.
- Access: multiple access/exit points
- Minimum toll segment: 1 mile
- HOV rate: No
- Trucks: Yes (different rate)
- Tolling Mechanism: ETC, coins, tokens
- Toll Unit: flat rates charged between exits and/or plazas
- Toll Range: $0.55 to $5.50 (distance based)
  - $0.45 to $4.60 off peak
  - Based on distance/exit or plaza
  - Extra cost for truck or bus
  - Discount for EZ Tag and weekend
- Toll per mile: $0.03 to $0.05 peak - $0.03 and $0.04 off peak

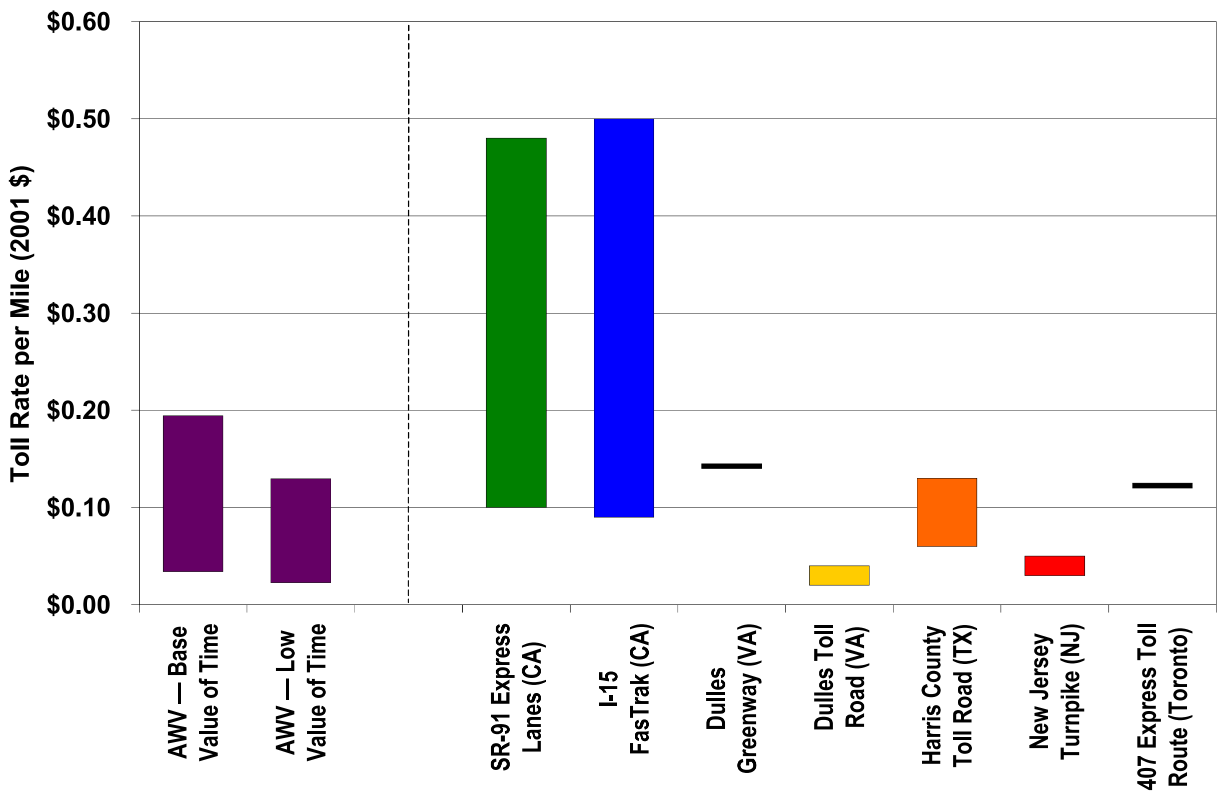
407 Express Toll Route (ETR), Toronto, Canada

- Year Opened: 1997
- Principal operating objective: Revenue maximization
- Length, Type & Location: 108 kilometers (68 miles) running east-west at the north edge of Toronto (from EW in the west to Highway 7 just east of Brock Road in the east).
- Minimum toll segment: approximately 5 km (3.1 mi)
- HOV rate: No
- Trucks: Yes (different rate)
- Tolling Mechanism: 100% ETC
- Toll unit: per kilometer between exits and/or plazas

- Toll Range: $0.12 US per mile
  - Higher fees for larger vehicles
- Note: Vehicles without transponder are billed via license plate recognition plus an administrative surcharge for processing. Large vehicles require a transponder.

Table 10 presents a comparison of the range of toll rates for the selected toll facilities to those proposed for the range of AWV alternatives in the opening year of 2009, *with all amounts shown in 2001 US dollars*. At only 4-5 miles in length, the AWV is by far the shortest of the other toll facilities listed above. Note also that several of these facilities have operating objectives that are most likely tied to revenue targets, such as debt service, which may result in a toll rate or time of day toll structure that is sub-optimal from the standpoint of economic efficiency.

Table 10
Comparison of Opening Year (2009) AWV Toll Rates with Selected North American Toll Road Rates in 2001 $



THE NEXT LEVEL: INVESTMENT GRADE TOLL REVENUE FORECASTS

By striking a balance between technical methods and resource constraints, the optimal toll estimates and resulting toll revenue forecasts presented herein represent "first cut" results. These results are intended to inform the consideration of implementing user fees on the AWV with the objective of identifying if tolls look promising enough to warrant further research.

Assuming that toll revenues look promising and are intended to serve as a primary source of funds from which to borrow against and cover debt service costs (e.g., the sale of revenue bonds), then the successful issuance of debt will likely require completion of a more thorough, "investment grade" toll traffic and revenue forecast study.

In a simplistic sense,"investment grade" revenue forecast is whatever set of assumptions, methods, and review procedures that are sufficiently conservative to instill the confidence of the bond rating agencies and financial markets. Specifically, a minimum "investment grade" rating from one or more rating agencies is necessary to achieve reasonable financing terms and cost-effectively sell toll revenue bonds.[11] Rating agencies such as Standard and Poor, Moodys and Fitch evaluate the revenue sources that would be dedicated to the repayment of bonds in order to rate the risk associated with a particular issuance. A proposed issuance that receives a rating is considered investment grade, and the better the rating, the more marketable the securities are and the lower the interest rate paid by the borrower, all else equal. Bonds that backed by revenue sources with sufficient uncertainty that they do not to get rated are known as sub-investment grade or "junk" bonds. Such bonds can be difficult to market, and result in very high interest costs as investors demand a premium return commensurate with the risks of default.

In order to obtain an investment grade rating, an independent third party must prepare a detailed traffic and revenue study that addresses all of the pertinent issues related to the toll revenue, including the elasticity of demand, demographic inputs (an independent view of this separate from the MPO), toll rates, operations and maintenance costs, etc.[12] In addition, investment grade forecasts tend to be distinguished from preliminary or planning grade results by their more rigorous and critical deliberation of assumptions, methods and review procedures at all stages. Finally, they typically result in a very thorough and professional report combined and in-person meeting with the rating agencies.

The actual assumptions, methods and review procedures for an investment grade study are not proscribed — in fact, they can vary across projects and be subject to considerable debate — rather it is the thorough consideration of risk variation, examination of inputs, validation tests, high standards of quality, and independent review at every step of the process that tend to characterize investment grade results. It should also be noted that investment grade results involve much more time consuming and costly efforts than do the initial planning level

[11] Financial assistance via the federal Transportation Infrastructure Finance and Innovation Act (TIFIA) also requires investment grade traffic and revenue forecasts.

[12] In the U.S. tax-exempt bond market, there are currently only a few firms that the rating agencies are willing to rely upon for these forecasts

forecasts. However, if preliminary revenue forecasts suggest tolls could back revenue bonds amounting to a significant share of project funding (which is not likely to be the case for the AWV), then investment grade forecasts are warranted and will pay for themselves by conveying and reducing risks as well as facilitating and lowering the cost of project financing.

AWV Toll Revenue Considerations

For the AWV project area comprised of the greater Seattle region, more detailed market research regarding the behavioral nature and characteristics of potential road users, including their willingness to pay tolls, is needed to inform investment grade forecasts. Similarly, extensive travel demand modeling with better tools are required to apply the results of such research and better estimate toll elasticities of demand. It is likely that investment grade results would require a development of a state-of-the-art travel demand forecasting model, or further refinement and modifications to the existing PSRC regional travel demand model, in order to provide adequate capabilities to conduct detailed sensitivity analysis of various pricing and travel benefit combinations. Development of such a tool would require a variety of professionals with specialized skills and experience in which the following activities would likely be undertaken.

- **Detailed market research, most likely including a stated-preference survey (SPS) —** Market research would need to be conducted to identify and gauge travel market behavior, willingness to pay by trip purpose, frequency, and income range, preferences regarding time and travel benefit trade-offs, and socio-economic aspects. If an existing toll facility with similar characteristics to the proposed facility serves the same or similar markets, then it may be possible to use revealed preference and/or panel survey data of the existing toll facility user market to identify likely behavior for the proposed facility. However, since there are no other comparable toll facilities operating in the Puget Sound Region to allow for this, it is essential that some SPS research be undertaken. The resulting survey information is required to provide pertinent quantitative data on potential toll users' sensitivity with respect to willingness-to-pay, socio-economic characteristics, and other travel behavior attributes. SPS data may need to be pooled with other travel survey data already collected by PSRC.

- **Develop a toll mode choice model —** A toll mode choice model would need to be developed to allow more accurate simulation of travel behavior decisions with respect to pricing trade-offs in the travel forecasting process. This task will also involve using appropriate statistical techniques to estimate toll elasticities of demand for various market segments. Such a toll mode choice model has been recently developed for facilities in Houston and Orlando.

- **Integrate the toll mode choice model with the applicable travel demand model —** The toll mode choice model would then be implemented within either a newly developed travel demand forecasting model or a modified and refined PSRC model. This task may involve reliance on experience from toll operations in other regions across the country (e.g., Houston, Orlando, San Diego, etc.)

- **Model and estimate toll revenues and/or toll pricing structures —** Upon fully completing data collection and model development, toll revenue forecasts would be prepared and/or toll pricing structures would be estimated according to desired facility and network operating objectives (e.g., revenue maximization, economically efficient toll, throughput targets, etc.)

- **Independent Review and Documentation** — A panel of independent experts would be assembled to review and comment on the modeling process and forecast results, which may result in further refinements and process iteration to refine the estimates. A technical report would then be prepared to document above efforts, methodology and results in such a manner as to convey the level of conservatism and risks in the results and inform experts in the finance industry.

A key product of this process would be reliable estimates for the toll elasticity of demand over a range of toll rates, trip purposes, and user demographics. This would facilitate the development of an optimum pricing structure to serve the real world operating objective(s), as well as allow for sensitivity analyses testing of different pricing schemes.

KEY FINDINGS

- **There is sufficient travel demand and congestion in the Alaskan Way Viaduct corridor to warrant the application of congestion pricing via tolls. At the same time, the relatively short distance combined with the existence of several substitute parallel routes and a lack of peak period reverse direction and off-peak period demand limits the ultimate revenue potential that could be achieved by creating a more extended north-south urban corridor.**
  - Moreover, the success of implementing pricing on any single roadway, including the AWV, will likely be enhanced to the extent that other facilities within the regional highway system adopt pricing management techniques and integrated electronic payment methods. In any event, tolling the AWV will cause some diversion to City streets and I-5, particularly in the absence of a system-wide approach to pricing.
  - The physical needs for electronic tolling and/or cash payment toll collection have not been analyzed herein. However, there will likely be some significant physical and geographical challenges to implementing a cash payment toll collection option, particularly with multiple access and egress points in both travel directions.
- **For the Alaskan Way Viaduct or its replacement, application of the economically efficient or optimal per-mile toll rates using only electronic toll collection can be expected to generate gross annual revenue within the range of $4.3 to 7.8 million in the opening year of 2009.**
  - This estimated range excludes probable demand ramp-up effects that would occur during the initial months of operation. Actual revenue will depend on users' values of time as indicative of willingness to pay, and the time periods for which tolls are to be charged. Demand and gross revenue would be approximately 10% higher with a delay-free cash payment method, but manual toll collection congestion impacts and costs may offset much of the additional revenue.
- **The optimal toll rates seek to minimize overall network travel times. These toll rates are likely to be less than those that would maximize revenue; however, the appropriate research and tools for determining the revenue maximizing tolls do not currently exist. Nonetheless, the revenue maximizing toll structure would likely result in additional diversion and, thus, greater social delay costs due to increased congestion on unpriced facilities.**
- **Each $1 million of annual toll revenue, net of any operating costs, could leverage approximately $7-10 million of capital investment, plus another $1-2 million toward a few years of capitalized debt service costs during construction, via the sale of municipal revenue bonds or similar debt instruments.**
  - For the AWV replacement, the range of projected toll revenue equates to a range capital investment purchasing power with a lower bound of $35 million and an upper bound of $95 million in project costs, including capitalized debt service.
  - Exact amounts would depend on debt service coverage requirements, issuance costs, debt terms and duration, and the duration of construction, among other variables.

- **Toll revenue under Alternative D in 2009 exceeds that of the existing facility by 15%, escalating to 23% by 2030. This is a function of the longer travel distance of Alternative D combined with similar time savings due to higher design standards. Other build alternatives with similar access points would likely generate toll revenue between these two endpoints.**
  - Design improvements of the build alternatives lead to marginally improved capacity, operating efficiency, and thus, higher demand. This is somewhat offset by longer travel distances, and overall, the build alternatives are likely to result in per-mile toll rates similar to those for the existing facility. However, certain build alternatives may yield somewhat higher revenues, due to the fact that tolls are charged over longer travel distances and for slightly higher traffic volumes.
  - If the proposed toll facility became part of a larger limited access north-south corridor connecting in with SR-509 in the south and I-5 in the north, then the resulting benefits, demand levels, and thus, toll revenue could be significantly higher.
- **In opening year 2009, the maximum one-way optimal toll charge projected for travel from end-to-end, in the peak direction during peak periods, would be about 50¢ for Alternative D.**
  - The true toll rate depends on the actual value of time or willingness to pay for delay reduction exhibited by the travel market, and the physical characteristics of the toll facility in terms of distance, design standards and access/connection points.
  - The revenue maximizing toll could be somewhat higher than the economically efficient toll presented herein. However, higher toll rates would cause more diversion to I-5 and city streets, and may not minimize overall network travel times.
- **The optimal toll rates will need to increase periodically due to both inflation and growing travel demand, if the roadway is to be managed to yield economically efficient network traffic levels to prevent congestion.**
  - Regular toll increases will require that the operating objectives and management policies of the facility be well established and clearly communicated to the public and policy-makers.
  - Toll diversion to other routes, modes, time of day as well as trip chaining and elimination is expected to average from 13% to 17% across alternatives and analysis years. Localized diversion between various access points may vary outside of this range.

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Table A- 1
Toll Rate per Mile Schedule for the Baseline "No-Action" Alternative
(Constant and Inflated Dollars — Low Value of Time)

Year	Constant Year 2000 Dollars				Inflated (Year of Expenditure) Dollars			
	Low Value of Time ($ / hr)	Peak Periods / Peak Direction	Peak Periods / Reverse Direction	Midday/ Evening & Weekend Both Dir	Low Value of Time ($ / hr)	Peak Periods / Peak Direction	Peak Periods / Reverse Direction	Midday & Weekend Both Directions
1998	$7.89	$0.07	$0.02	$0.02	$7.56	$0.07	$0.02	$0.02
1999	$7.89	$0.07	$0.02	$0.02	$7.68	$0.07	$0.02	$0.02
2000	$7.89	$0.07	$0.03	$0.02	$7.89	$0.07	$0.03	$0.02
2001	$7.89	$0.07	$0.03	$0.02	$8.04	$0.08	$0.03	$0.02
2002	$7.89	$0.07	$0.03	$0.02	$8.11	$0.08	$0.03	$0.02
2003	$7.89	$0.08	$0.03	$0.02	$8.29	$0.08	$0.03	$0.02
2004	$7.89	$0.08	$0.03	$0.02	$8.48	$0.08	$0.03	$0.02
2005	$7.89	$0.08	$0.03	$0.02	$8.67	$0.08	$0.03	$0.02
2006	$7.89	$0.08	$0.03	$0.02	$8.86	$0.09	$0.03	$0.03
2007	$7.89	$0.08	$0.03	$0.02	$9.06	$0.09	$0.03	$0.03
2008	$7.89	$0.08	$0.03	$0.02	$9.26	$0.09	$0.03	$0.03
2009	$7.89	$0.08	$0.03	$0.02	$9.47	$0.09	$0.04	$0.03
2010	$7.89	$0.08	$0.03	$0.02	$9.69	$0.10	$0.04	$0.03
2011	$7.89	$0.08	$0.03	$0.02	$9.93	$0.10	$0.04	$0.03
2012	$7.89	$0.08	$0.03	$0.02	$10.20	$0.10	$0.04	$0.03
2013	$7.89	$0.08	$0.03	$0.02	$10.49	$0.11	$0.04	$0.03
2014	$7.89	$0.08	$0.03	$0.02	$10.79	$0.11	$0.04	$0.03
2015	$7.89	$0.08	$0.03	$0.02	$11.10	$0.12	$0.05	$0.03
2016	$7.89	$0.08	$0.03	$0.02	$11.42	$0.12	$0.05	$0.03
2017	$7.89	$0.08	$0.03	$0.02	$11.77	$0.13	$0.05	$0.03
2018	$7.89	$0.08	$0.03	$0.02	$12.17	$0.13	$0.05	$0.04
2019	$7.89	$0.09	$0.04	$0.02	$12.60	$0.14	$0.06	$0.04
2020	$7.89	$0.09	$0.04	$0.02	$13.07	$0.14	$0.06	$0.04
2021	$7.89	$0.09	$0.04	$0.02	$13.39	$0.15	$0.06	$0.04
2022	$7.89	$0.09	$0.04	$0.02	$13.72	$0.15	$0.06	$0.04
2023	$7.89	$0.09	$0.04	$0.02	$14.07	$0.16	$0.07	$0.04
2024	$7.89	$0.09	$0.04	$0.02	$14.43	$0.16	$0.07	$0.04
2025	$7.89	$0.09	$0.04	$0.02	$14.79	$0.17	$0.07	$0.04
2026	$7.89	$0.09	$0.04	$0.02	$15.17	$0.17	$0.08	$0.04
2027	$7.89	$0.09	$0.04	$0.02	$15.57	$0.18	$0.08	$0.04
2028	$7.89	$0.09	$0.04	$0.02	$15.99	$0.19	$0.08	$0.05
2029	$7.89	$0.09	$0.04	$0.02	$16.42	$0.19	$0.09	$0.05
2030	$7.89	$0.09	$0.04	$0.02	$16.86	$0.20	$0.09	$0.05

Note: Toll operations not expected to commence prior to 2009

Table A- 2
Toll Rate per Mile Schedule for Alternative D
(Constant and Inflated Dollars — Low Value of Time)

Year	Constant Year 2000 Dollars				Inflated (Year of Expenditure) Dollars			
	Low Value of Time ($ / hr)	Peak Periods / Peak Direction	Peak Periods / Reverse Direction	Midday/ Evening & Weekend Both Dir	Low Value of Time ($ / hr)	Peak Periods / Peak Direction	Peak Periods / Reverse Direction	Midday & Weekend Both Directions
1998	$7.89	$0.06	$0.02	$0.02	$7.56	$0.06	$0.02	$0.02
1999	$7.89	$0.07	$0.02	$0.02	$7.68	$0.06	$0.02	$0.02
2000	$7.89	$0.07	$0.02	$0.02	$7.89	$0.07	$0.02	$0.02
2001	$7.89	$0.07	$0.02	$0.02	$8.04	$0.07	$0.02	$0.02
2002	$7.89	$0.07	$0.02	$0.02	$8.11	$0.07	$0.03	$0.02
2003	$7.89	$0.07	$0.03	$0.02	$8.29	$0.07	$0.03	$0.02
2004	$7.89	$0.07	$0.03	$0.02	$8.48	$0.07	$0.03	$0.02
2005	$7.89	$0.07	$0.03	$0.02	$8.67	$0.07	$0.03	$0.02
2006	$7.89	$0.07	$0.03	$0.02	$8.86	$0.08	$0.03	$0.02
2007	$7.89	$0.07	$0.03	$0.02	$9.06	$0.08	$0.03	$0.02
2008	$7.89	$0.07	$0.03	$0.02	$9.26	$0.08	$0.03	$0.02
2009	$7.89	$0.07	$0.03	$0.02	$9.47	$0.08	$0.03	$0.02
2010	$7.89	$0.07	$0.03	$0.02	$9.69	$0.08	$0.04	$0.03
2011	$7.89	$0.07	$0.03	$0.02	$9.93	$0.09	$0.04	$0.03
2012	$7.89	$0.07	$0.03	$0.02	$10.20	$0.09	$0.04	$0.03
2013	$7.89	$0.07	$0.03	$0.02	$10.49	$0.09	$0.04	$0.03
2014	$7.89	$0.07	$0.03	$0.02	$10.79	$0.10	$0.04	$0.03
2015	$7.89	$0.07	$0.03	$0.02	$11.10	$0.10	$0.05	$0.03
2016	$7.89	$0.07	$0.03	$0.02	$11.42	$0.10	$0.05	$0.03
2017	$7.89	$0.07	$0.03	$0.02	$11.77	$0.11	$0.05	$0.03
2018	$7.89	$0.07	$0.04	$0.02	$12.17	$0.11	$0.05	$0.03
2019	$7.89	$0.07	$0.04	$0.02	$12.60	$0.12	$0.06	$0.03
2020	$7.89	$0.07	$0.04	$0.02	$13.07	$0.12	$0.06	$0.04
2021	$7.89	$0.07	$0.04	$0.02	$13.39	$0.12	$0.06	$0.04
2022	$7.89	$0.07	$0.04	$0.02	$13.72	$0.13	$0.07	$0.04
2023	$7.89	$0.07	$0.04	$0.02	$14.07	$0.13	$0.07	$0.04
2024	$7.89	$0.07	$0.04	$0.02	$14.43	$0.14	$0.07	$0.04
2025	$7.89	$0.08	$0.04	$0.02	$14.79	$0.14	$0.08	$0.04
2026	$7.89	$0.08	$0.04	$0.02	$15.17	$0.15	$0.08	$0.04
2027	$7.89	$0.08	$0.04	$0.02	$15.57	$0.15	$0.09	$0.05
2028	$7.89	$0.08	$0.04	$0.02	$15.99	$0.16	$0.09	$0.05
2029	$7.89	$0.08	$0.05	$0.02	$16.42	$0.16	$0.09	$0.05
2030	$7.89	$0.08	$0.05	$0.02	$16.86	$0.17	$0.10	$0.05

Note: Toll operations not expected to commence prior to 2009

Table A- 3
Applied Weekday Model Volumes and V/C Ratios by Period — Baseline Alternative

Link Distance (mi.)	Description	Daily Volumes Without Tolls 1998	2009	2030	Daily Volumes With Tolls (Excl. ETC Adjustments) 1998	2009	2030	Diversion Due to Tolling 1998	2009	2030
0.49	Spokane St/SR-99 Interchange	54,207	59,549	71,254	46,960	50,715	58,738	-13.4%	-14.8%	-17.6%
1.32	SR99 from Spokane St to S. Atlantic St	99,189	104,317	114,856	87,571	90,812	97,336	-11.7%	-12.9%	-15.3%
0.53	SR99 from S. Atlantic St to 1st Ave Ramps	99,189	104,317	114,856	87,571	90,812	97,336	-11.7%	-12.9%	-15.3%
0.20	AWV from 1st Ave Ramps to Yesler Way	130,527	135,779	146,401	115,813	118,699	124,408	-11.3%	-12.6%	-15.0%
0.14	AWV from Yesler Way to Columbia St	130,527	135,779	146,401	115,813	118,699	124,408	-11.3%	-12.6%	-15.0%
0.23	AWV from Columbia St to Seneca St	115,488	121,253	133,069	102,056	105,762	113,215	-11.6%	-12.8%	-14.9%
0.45	AWV from Seneca St to Western/Elliot Ave	102,038	108,217	121,073	89,256	93,343	101,673	-12.5%	-13.7%	-16.0%
0.06	SR 99-Elliot Ave/Western Ave I/C to Battery St Tunnel - A	78,280	84,347	97,266	66,115	70,057	78,249	-15.5%	-16.9%	-19.6%
0.21	SR 99-Elliot Ave/Western Ave I/C to Battery St Tunnel - B	60,574	66,411	79,164	48,892	52,552	60,316	-19.3%	-20.9%	-23.8%
0.29	Battery St tunnel	70,565	75,805	86,915	58,177	61,088	67,056	-17.6%	-19.4%	-22.8%
0.10	Battery St tunnel up to Denny Way Ramps	70,565	75,805	86,915	58,177	61,088	67,056	-17.6%	-19.4%	-22.8%
	Weighted Averages	**92,502**	**97,883**	**109,109**	**80,835**	**84,230**	**91,159**	**-12.6%**	**-13.9%**	**-16.5%**

Time Period & Direction	Wt. Average V/C Without Tolls 1998	2009	2030	Wt. Average V/C With Tolls (Excl. ETC Adjustments) 1998	2009	2030	Percent Change Due to Tolling 1998	2009	2030
AM / PM Peak Periods, Peak Direction	1.12	1.10	1.08	0.92	0.95	0.99	-17.3%	-14.3%	-8.2%
AM / PM Peak Periods, Non-Peak Direction	0.76	0.83	0.98	0.71	0.75	0.82	-5.6%	-9.3%	-16.0%
Midday Period, Southbound	0.57	0.60	0.67	0.70	0.70	0.70	22.4%	16.0%	4.7%
Midday Period, Northbound	0.54	0.57	0.63	0.70	0.64	0.55	30.5%	13.2%	-13.6%
Night Periods, Both Directions	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Table A- 4
Applied Weekday Model Volumes and V/C Ratios by Period — Alternative D

Link Distance (mi.)	*Description*	*Daily Volumes Without Tolls* 1998	2009	2030	*Daily Volumes With Tolls (Excl. ETC Adjustments)* 1998	2009	2030	*Diversion Due to Tolling* 1998	2009	2030
0.49	Spokane St/SR-99 Interchange	55,734	61,825	75,363	50,708	55,519	66,005	-9.0%	-10.2%	-12.4%
1.32	SR99 from Spokane St to S. Atlantic St	129,973	136,484	149,833	111,770	115,982	124,471	-14.0%	-15.0%	-16.9%
0.53	SR99 from S. Atlantic St to 1st Ave Ramps	106,142	111,765	123,340	91,030	95,109	103,411	-14.2%	-14.9%	-16.2%
0.20	AWV from 1st Ave Ramps to Yesler Way	123,298	128,443	138,869	107,476	110,964	117,940	-12.8%	-13.6%	-15.1%
0.14	AWV from Yesler Way to Columbia St	82,943	114,900	104,749	69,957	97,953	84,711	-13.4%	-14.7%	-17.2%
0.23	AWV from Columbia St to Seneca St	96,418	102,901	116,512	82,629	86,843	95,494	-14.3%	-15.6%	-18.0%
0.22	AWV from Seneca St to Ramps north of Seneca St	82,943	89,872	104,749	69,957	74,713	84,711	-15.7%	-16.9%	-19.1%
0.45	AWV from Ramps north of Seneca St to Bell St	108,375	114,900	128,467	93,809	97,953	106,377	-13.4%	-14.7%	-17.2%
0.12	AWV from Bell St to Wall St	108,375	114,900	128,467	93,809	97,953	106,377	-13.4%	-14.7%	-17.2%
0.30	AWV from Wall St to Ramps from/to Elliot Ave	108,375	114,900	128,467	93,809	97,953	106,377	-13.4%	-14.7%	-17.2%
0.16	AWV from Ramps from/to Elliot Ave to Ist Ave	71,355	77,531	90,843	58,408	62,424	70,875	-18.1%	-19.5%	-22.0%
0.33	AWV from 1st Ave to Thomas St	71,355	77,531	90,843	58,408	62,424	70,875	-18.1%	-19.5%	-22.0%
0.30	AWV from Thomas St to Republican St	71,355	77,531	90,843	58,408	62,424	70,875	-18.1%	-19.5%	-22.0%
0.14	AWV from Republican St to Aurora & Roy St	46,245	52,168	65,661	40,355	44,583	53,925	-12.7%	-14.5%	-17.9%
	Weighted Averages	**99,180**	**106,170**	**118,678**	**85,136**	**90,021**	**98,091**	**-14.2%**	**-15.2%**	**-17.3%**

Time Period & Direction	*Wt. Average V/C Without Tolls* 1998	2009	2030	*Wt. Average V/C With Tolls (Excl. ETC Adjustments)* 1998	2009	2030	*Percent Change Due to Tolling* 1998	2009	2030
AM / PM Peak Periods, Peak Direction	1.01	1.01	1.01	0.87	0.89	0.93	-13.8%	-12.1%	-8.8%
AM / PM Peak Periods, Non-Peak Direction	0.72	0.80	0.96	0.73	0.76	0.82	0.3%	-5.1%	-14.8%
Midday Period, Southbound	0.51	0.54	0.61	0.70	0.70	0.71	36.6%	28.9%	15.4%
Midday Period, Northbound	0.47	0.52	0.62	0.70	0.70	0.71	48.2%	35.0%	13.0%
Night Periods, Both Directions	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Table A- 5
Total & Toll Period Vehicle-Miles Traveled by Time Period — Baseline Alternative

Before ETC Non-Participation / Evasion Adjustments

	AM Peak (3 hr)		*PM Peak (4 hr)*		*Midday (6 hr)*		*Night (11 hr)*		*Weekday (24 hr)*		*Weekday Tolled (15 hr)*		*Weekend (24 hr)*		*Weekend Tolled (15 hr)*	
Year	*NB*	*SB*	*NB*	*SB*	*NB*	*SB*	*NB*	*SB*	*NB*	*SB*	*NB*	*SB*	*NB*	*SB*	*NB*	*SB*
									100.0%	*100.0%*	*86.2%*	*85.9%*	*100.0%*	*100.0%*	*77.1%*	*77.1%*
2009	38,995	28,377	37,835	51,994	68,361	70,250	23,331	24,778	168,523	175,398	145,192	150,620	84,261	87,699	64,979	67,630
2010	39,085	28,581	38,108	52,114	68,549	70,506	23,442	24,890	169,185	176,091	145,743	151,201	84,592	88,046	65,234	67,898
2011	39,175	28,787	38,383	52,234	68,738	70,764	23,553	25,003	169,850	176,788	146,296	151,785	84,925	88,394	65,491	68,166
2012	39,266	28,994	38,659	52,354	68,927	71,023	23,666	25,116	170,518	177,488	146,852	152,372	85,259	88,744	65,749	68,436
2013	39,356	29,203	38,938	52,475	69,117	71,283	23,778	25,230	171,189	178,192	147,411	152,961	85,595	89,096	66,007	68,707
2014	39,447	29,414	39,218	52,596	69,307	71,543	23,892	25,345	171,864	178,898	147,972	153,553	85,932	89,449	66,268	68,980
2015	39,538	29,626	39,501	52,718	69,498	71,805	24,005	25,460	172,542	179,608	148,537	154,148	86,271	89,804	66,529	69,254
2016	39,629	29,839	39,785	52,839	69,689	72,067	24,120	25,575	173,223	180,321	149,104	154,746	86,612	90,161	66,792	69,529
2017	39,721	30,054	40,072	52,961	69,881	72,331	24,235	25,691	173,908	181,037	149,673	155,346	86,954	90,519	67,056	69,805
2018	39,812	30,271	40,361	53,083	70,073	72,595	24,350	25,808	174,596	181,757	150,246	155,949	87,298	90,879	67,321	70,082
2019	39,904	30,489	40,652	53,206	70,266	72,861	24,466	25,925	175,288	182,480	150,822	156,555	87,644	91,240	67,588	70,361
2020	39,996	30,708	40,945	53,328	70,459	73,127	24,583	26,043	175,983	183,207	151,400	157,164	87,991	91,603	67,856	70,641
2021	40,089	30,930	41,240	53,451	70,653	73,395	24,700	26,161	176,681	183,937	151,981	157,776	88,340	91,968	68,125	70,923
2022	40,181	31,153	41,537	53,575	70,847	73,663	24,817	26,279	177,382	184,670	152,565	158,390	88,691	92,335	68,395	71,205
2023	40,274	31,377	41,836	53,698	71,042	73,932	24,936	26,399	178,088	185,406	153,152	159,008	89,044	92,703	68,667	71,489
2024	40,367	31,603	42,138	53,822	71,237	74,203	25,054	26,518	178,796	186,146	153,742	159,628	89,398	93,073	68,941	71,775
2025	40,460	31,831	42,441	53,946	71,433	74,474	25,174	26,639	179,508	186,890	154,334	160,251	89,754	93,445	69,215	72,061
2026	40,553	32,060	42,747	54,071	71,630	74,746	25,294	26,760	180,224	187,637	154,930	160,877	90,112	93,818	69,491	72,349
2027	40,647	32,291	43,055	54,196	71,827	75,019	25,414	26,881	180,943	188,387	155,529	161,506	90,471	94,194	69,768	72,639
2028	40,740	32,524	43,365	54,321	72,025	75,294	25,535	27,003	181,666	189,141	156,130	162,138	90,833	94,571	70,047	72,929
2029	40,834	32,758	43,678	54,446	72,223	75,569	25,657	27,126	182,392	189,899	156,735	162,773	91,196	94,949	70,327	73,221
2030	40,929	32,994	43,992	54,571	72,421	75,845	25,779	27,249	183,122	190,660	157,342	163,411	91,561	95,330	70,608	73,515

Note: Toll operations not expected to commence prior to 2009

Table A- 6
Total & Toll Period Vehicle-Miles Traveled by Time Period — Alternative D

Before ETC Non-Participation / Evasion Adjustments

	AM Peak (3 hr)		PM Peak (4 hr)		Midday (6 hr)		Night (11 hr)		Weekday (24 hr)		Weekday Tolled (15 hr)		Weekend (24 hr)		Weekend Tolled (15 hr)	
Year	NB	SB	NB	SB	NB	SB	NB	SB	NB	SB	NB	SB	NB	SB	NB	SB
									100.0%	100.0%	85.7%	85.7%	100.0%	100.0%	77.1%	77.1%
2009	49,244	37,790	50,387	65,658	89,543	89,798	31,470	32,179	220,643	225,425	189,173	193,246	110,322	112,712	85,076	86,920
2010	49,367	38,090	50,786	65,823	89,926	90,158	31,699	32,345	221,778	226,416	190,079	194,070	110,889	113,208	85,514	87,302
2011	49,491	38,391	51,188	65,988	90,311	90,520	31,929	32,512	222,920	227,412	190,990	194,899	111,460	113,706	85,954	87,686
2012	49,615	38,695	51,594	66,153	90,698	90,884	32,161	32,680	224,068	228,413	191,906	195,732	112,034	114,206	86,397	88,072
2013	49,739	39,002	52,003	66,319	91,086	91,249	32,395	32,849	225,223	229,419	192,828	196,570	112,611	114,710	86,842	88,460
2014	49,864	39,311	52,415	66,485	91,476	91,615	32,631	33,019	226,385	230,431	193,754	197,412	113,193	115,215	87,290	88,850
2015	49,989	39,623	52,830	66,652	91,867	91,983	32,868	33,190	227,554	231,448	194,686	198,258	113,777	115,724	87,741	89,242
2016	50,114	39,936	53,249	66,819	92,260	92,353	33,107	33,361	228,730	232,470	195,623	199,108	114,365	116,235	88,194	89,636
2017	50,240	40,253	53,671	66,987	92,655	92,724	33,347	33,534	229,913	233,497	196,566	199,963	114,957	116,748	88,650	90,032
2018	50,366	40,572	54,096	67,155	93,052	93,096	33,590	33,707	231,103	234,529	197,513	200,822	115,552	117,265	89,109	90,430
2019	50,492	40,893	54,524	67,323	93,450	93,470	33,834	33,881	232,301	235,567	198,466	201,686	116,150	117,784	89,571	90,830
2020	50,619	41,217	54,956	67,492	93,850	93,845	34,080	34,056	233,505	236,610	199,425	202,554	116,753	118,305	90,035	91,233
2021	50,746	41,544	55,392	67,661	94,251	94,222	34,328	34,232	234,717	237,659	200,389	203,427	117,358	118,830	90,503	91,637
2022	50,873	41,873	55,831	67,831	94,655	94,601	34,577	34,409	235,936	238,713	201,358	204,304	117,968	119,357	90,973	92,044
2023	51,001	42,205	56,273	68,001	95,060	94,981	34,829	34,587	237,162	239,773	202,333	205,186	118,581	119,886	91,445	92,452
2024	51,128	42,539	56,719	68,171	95,467	95,362	35,082	34,766	238,396	240,838	203,314	206,072	119,198	120,419	91,921	92,863
2025	51,257	42,876	57,168	68,342	95,875	95,745	35,337	34,945	239,637	241,909	204,300	206,963	119,819	120,954	92,400	93,276
2026	51,385	43,216	57,621	68,513	96,286	96,130	35,594	35,126	240,886	242,985	205,292	207,859	120,443	121,492	92,881	93,691
2027	51,514	43,558	58,078	68,685	96,698	96,516	35,853	35,307	242,142	244,066	206,289	208,759	121,071	122,033	93,366	94,108
2028	51,643	43,903	58,538	68,857	97,112	96,903	36,113	35,490	243,406	245,154	207,293	209,664	121,703	122,577	93,853	94,527
2029	51,773	44,251	59,002	69,030	97,527	97,292	36,376	35,673	244,677	246,247	208,301	210,574	122,339	123,123	94,343	94,948
2030	51,902	44,602	59,469	69,203	97,945	97,683	36,640	35,857	245,956	247,346	209,316	211,488	122,978	123,673	94,836	95,372

Note: Toll operations not expected to commence prior to 2009

Table A- 7
Weekday and Weekend Toll Revenue for the Baseline "No Action" Alternative — Constant 2000 Dollars

Year	Gross Weekday Revenue (2000 $)		Adjustments for Truck Toll Rates (+) & ETC Violators/ AVI Non-Participation (–)		Net Weekday Revenue (2000 $)		Gross Weekend Day Revenue (2000 $)		Adjustments for Truck Toll Rates (+) & ETC Violators/ AVI Non-Participation (–)		Net Weekend Day Revenue (2000 $)	
	NB	SB	NB	SB	NB	SB	NB	SB	NB	SB	NB	SB
2009	$9,419	$10,649	($11)	($12)	$9,408	$10,636	$2,215	$2,305	($3)	($3)	$2,212	$2,303
2010	$9,517	$10,755	($11)	($13)	$9,506	$10,742	$2,224	$2,314	($3)	($3)	$2,221	$2,312
2011	$9,617	$10,862	($11)	($13)	$9,606	$10,849	$2,232	$2,324	($3)	($3)	$2,230	$2,321
2012	$9,719	$10,971	($11)	($13)	$9,708	$10,958	$2,241	$2,333	($3)	($3)	$2,239	$2,330
2013	$9,822	$11,081	($11)	($13)	$9,811	$11,068	$2,250	$2,342	($3)	($3)	$2,247	$2,339
2014	$9,927	$11,193	($12)	($13)	$9,916	$11,180	$2,259	$2,351	($3)	($3)	$2,256	$2,349
2015	$10,034	$11,307	($12)	($13)	$10,022	$11,293	$2,268	$2,361	($3)	($3)	$2,265	$2,358
2016	$10,142	$11,422	($12)	($13)	$10,130	$11,408	$2,277	$2,370	($3)	($3)	$2,274	$2,367
2017	$10,252	$11,538	($12)	($13)	$10,240	$11,525	$2,286	$2,379	($3)	($3)	$2,283	$2,377
2018	$10,364	$11,657	($12)	($14)	$10,352	$11,643	$2,295	$2,389	($3)	($3)	$2,292	$2,386
2019	$10,478	$11,777	($12)	($14)	$10,466	$11,763	$2,304	$2,398	($3)	($3)	$2,301	$2,396
2020	$10,594	$11,899	($12)	($14)	$10,581	$11,885	$2,313	$2,408	($3)	($3)	$2,310	$2,405
2021	$10,711	$12,022	($13)	($14)	$10,698	$12,008	$2,322	$2,418	($3)	($3)	$2,319	$2,415
2022	$10,830	$12,147	($13)	($14)	$10,818	$12,133	$2,331	$2,427	($3)	($3)	$2,329	$2,424
2023	$10,952	$12,275	($13)	($14)	$10,939	$12,260	$2,341	$2,437	($3)	($3)	$2,338	$2,434
2024	$11,075	$12,403	($13)	($14)	$11,062	$12,389	$2,350	$2,447	($3)	($3)	$2,347	$2,444
2025	$11,200	$12,534	($13)	($15)	$11,187	$12,520	$2,359	$2,456	($3)	($3)	$2,357	$2,453
2026	$11,328	$12,667	($13)	($15)	$11,315	$12,652	$2,369	$2,466	($3)	($3)	$2,366	$2,463
2027	$11,458	$12,802	($13)	($15)	$11,444	$12,787	$2,378	$2,476	($3)	($3)	$2,375	$2,473
2028	$11,589	$12,938	($14)	($15)	$11,576	$12,923	$2,388	$2,486	($3)	($3)	$2,385	$2,483
2029	$11,723	$13,077	($14)	($15)	$11,710	$13,062	$2,397	$2,496	($3)	($3)	$2,394	$2,493
2030	$11,860	$13,218	($14)	($15)	$11,846	$13,202	$2,407	$2,506	($3)	($3)	$2,404	$2,503

Table A- 8
Weekday and Weekend Toll Revenue for the Baseline "No Action" Alternative — Inflated Dollars

Year	Gross Weekday Revenue (Inflated $)		Adjustments for Truck Toll Rates (+) & ETC Violators/ AVI Non-Participation (–)		Net Weekday Revenue (Inflated $)		Gross Weekend Day Revenue (Inflated $)		Adjustments for Truck Toll Rates (+) & ETC Violators/ AVI Non-Participation (–)		Net Weekend Day Revenue (Inflated $)	
	NB	SB	NB	SB	NB	SB	NB	SB	NB	SB	NB	SB
2009	$11,307	$12,783	($13)	($15)	$11,294	$12,768	$2,659	$2,767	($3)	($3)	$2,656	$2,764
2010	$11,689	$13,208	($14)	($15)	$11,675	$13,193	$2,731	$2,842	($3)	($3)	$2,728	$2,839
2011	$12,104	$13,671	($14)	($16)	$12,090	$13,655	$2,810	$2,924	($3)	($3)	$2,806	$2,921
2012	$12,569	$14,188	($15)	($17)	$12,554	$14,171	$2,898	$3,017	($3)	($4)	$2,895	$3,013
2013	$13,066	$14,740	($15)	($17)	$13,051	$14,723	$2,993	$3,115	($3)	($4)	$2,989	$3,112
2014	$13,580	$15,311	($16)	($18)	$13,564	$15,293	$3,090	$3,216	($4)	($4)	$3,086	$3,213
2015	$14,120	$15,911	($16)	($19)	$14,103	$15,892	$3,191	$3,322	($4)	($4)	$3,187	$3,318
2016	$14,690	$16,543	($17)	($19)	$14,673	$16,523	$3,297	$3,433	($4)	($4)	$3,294	$3,429
2017	$15,304	$17,224	($18)	($20)	$15,287	$17,204	$3,412	$3,552	($4)	($4)	$3,408	$3,548
2018	$15,987	$17,981	($19)	($21)	$15,968	$17,960	$3,540	$3,685	($4)	($4)	$3,536	$3,681
2019	$16,733	$18,807	($20)	($22)	$16,713	$18,785	$3,679	$3,830	($4)	($4)	$3,675	$3,826
2020	$17,560	$19,723	($21)	($23)	$17,539	$19,700	$3,834	$3,991	($4)	($5)	$3,830	$3,987
2021	$18,187	$20,413	($21)	($24)	$18,166	$20,389	$3,943	$4,105	($5)	($5)	$3,938	$4,100
2022	$18,841	$21,133	($22)	($25)	$18,819	$21,108	$4,056	$4,223	($5)	($5)	$4,051	$4,218
2023	$19,532	$21,891	($23)	($26)	$19,509	$21,865	$4,174	$4,346	($5)	($5)	$4,170	$4,341
2024	$20,256	$22,685	($24)	($27)	$20,232	$22,659	$4,298	$4,475	($5)	($5)	$4,293	$4,469
2025	$21,007	$23,509	($25)	($27)	$20,982	$23,481	$4,425	$4,607	($5)	($5)	$4,420	$4,602
2026	$21,793	$24,369	($25)	($28)	$21,768	$24,341	$4,557	$4,745	($5)	($6)	$4,552	$4,739
2027	$22,625	$25,279	($26)	($30)	$22,599	$25,250	$4,696	$4,889	($5)	($6)	$4,691	$4,884
2028	$23,495	$26,230	($27)	($31)	$23,467	$26,199	$4,840	$5,040	($6)	($6)	$4,835	$5,034
2029	$24,403	$27,221	($29)	($32)	$24,375	$27,189	$4,990	$5,195	($6)	($6)	$4,984	$5,189
2030	$25,353	$28,256	($30)	($33)	$25,323	$28,223	$5,145	$5,357	($6)	($6)	$5,139	$5,351

Table A- 9
Weekday and Weekend Daily Toll Revenue for "Alternative D" — Constant 2000 Dollars

Year	Gross Weekday Revenue (2000 $)		Adjustments for Truck Toll Rates (+) & ETC Violators/ AVI Non-Participation (–)		Net Weekday Revenue (2000 $)		Gross Weekend Day Revenue (2000 $)		Adjustments for Truck Toll Rates (+) & ETC Violators/ AVI Non-Participation (–)		Net Weekend Day Revenue (2000 $)	
	NB	SB	NB	SB	NB	SB	NB	SB	NB	SB	NB	SB
2009	$10,952	$12,128	($13)	($14)	$10,939	$12,114	$2,600	$2,656	($3)	($3)	$2,597	$2,653
2010	$11,104	$12,274	($13)	($14)	$11,091	$12,260	$2,631	$2,686	($3)	($3)	$2,627	$2,682
2011	$11,258	$12,423	($13)	($15)	$11,245	$12,408	$2,662	$2,715	($3)	($3)	$2,659	$2,712
2012	$11,416	$12,574	($13)	($15)	$11,403	$12,559	$2,693	$2,745	($3)	($3)	$2,690	$2,742
2013	$11,577	$12,727	($14)	($15)	$11,563	$12,713	$2,725	$2,776	($3)	($3)	$2,722	$2,773
2014	$11,741	$12,884	($14)	($15)	$11,727	$12,869	$2,757	$2,807	($3)	($3)	$2,754	$2,803
2015	$11,908	$13,043	($14)	($15)	$11,894	$13,027	$2,790	$2,838	($3)	($3)	$2,787	$2,835
2016	$12,078	$13,204	($14)	($15)	$12,064	$13,189	$2,823	$2,869	($3)	($3)	$2,820	$2,866
2017	$12,252	$13,369	($14)	($16)	$12,238	$13,353	$2,857	$2,901	($3)	($3)	$2,853	$2,898
2018	$12,430	$13,536	($15)	($16)	$12,415	$13,521	$2,891	$2,933	($3)	($3)	$2,887	$2,930
2019	$12,611	$13,707	($15)	($16)	$12,596	$13,691	$2,925	$2,966	($3)	($3)	$2,922	$2,963
2020	$12,796	$13,880	($15)	($16)	$12,781	$13,864	$2,960	$2,999	($3)	($4)	$2,956	$2,996
2021	$12,985	$14,057	($15)	($16)	$12,969	$14,041	$2,995	$3,032	($3)	($4)	$2,991	$3,029
2022	$13,177	$14,237	($15)	($17)	$13,162	$14,220	$3,031	$3,066	($4)	($4)	$3,027	$3,063
2023	$13,374	$14,420	($16)	($17)	$13,358	$14,403	$3,067	$3,100	($4)	($4)	$3,063	$3,097
2024	$13,574	$14,607	($16)	($17)	$13,559	$14,589	$3,103	$3,135	($4)	($4)	$3,099	$3,131
2025	$13,779	$14,796	($16)	($17)	$13,763	$14,779	$3,140	$3,170	($4)	($4)	$3,136	$3,166
2026	$13,989	$14,990	($16)	($18)	$13,972	$14,972	$3,177	$3,205	($4)	($4)	$3,174	$3,201
2027	$14,202	$15,187	($17)	($18)	$14,186	$15,169	$3,215	$3,241	($4)	($4)	$3,211	$3,237
2028	$14,420	$15,388	($17)	($18)	$14,404	$15,370	$3,254	$3,277	($4)	($4)	$3,250	$3,273
2029	$14,643	$15,592	($17)	($18)	$14,626	$15,574	$3,292	$3,313	($4)	($4)	$3,288	$3,310
2030	$14,871	$15,801	($17)	($18)	$14,854	$15,783	$3,332	$3,350	($4)	($4)	$3,328	$3,346

Table A- 10
Weekday and Weekend Toll Revenue for "Alternative D" — Inflated Dollars

Year	Gross Weekday Revenue (Inflated $)		Adjustments for Truck Toll Rates (+) & ETC Violators/ AVI Non-Participation (–)		Net Weekday Revenue (Inflated $)		Gross Weekend Day Revenue (Inflated $)		Adjustments for Truck Toll Rates (+) & ETC Violators/ AVI Non-Participation (–)		Net Weekend Day Revenue (Inflated $)	
	NB	SB	NB	SB	NB	SB	NB	SB	NB	SB	NB	SB
2009	$13,147	$14,560	($15)	($17)	$13,132	$14,543	$3,121	$3,189	($4)	($4)	$3,117	$3,185
2010	$13,637	$15,075	($16)	($18)	$13,621	$15,057	$3,231	$3,298	($4)	($4)	$3,227	$3,294
2011	$14,170	$15,635	($17)	($18)	$14,153	$15,617	$3,350	$3,417	($4)	($4)	$3,346	$3,413
2012	$14,763	$16,261	($17)	($19)	$14,746	$16,242	$3,483	$3,550	($4)	($4)	$3,479	$3,546
2013	$15,399	$16,930	($18)	($20)	$15,381	$16,910	$3,625	$3,693	($4)	($4)	$3,621	$3,688
2014	$16,060	$17,623	($19)	($21)	$16,041	$17,603	$3,772	$3,839	($4)	($4)	$3,767	$3,835
2015	$16,757	$18,354	($20)	($21)	$16,737	$18,332	$3,926	$3,993	($5)	($5)	$3,922	$3,989
2016	$17,494	$19,125	($20)	($22)	$17,473	$19,102	$4,089	$4,156	($5)	($5)	$4,084	$4,151
2017	$18,290	$19,957	($21)	($23)	$18,269	$19,933	$4,264	$4,331	($5)	($5)	$4,259	$4,326
2018	$19,174	$20,880	($22)	($24)	$19,151	$20,856	$4,459	$4,525	($5)	($5)	$4,454	$4,520
2019	$20,139	$21,889	($24)	($26)	$20,116	$21,863	$4,671	$4,737	($5)	($6)	$4,666	$4,731
2020	$21,211	$23,008	($25)	($27)	$21,186	$22,981	$4,906	$4,971	($6)	($6)	$4,900	$4,966
2021	$22,048	$23,869	($26)	($28)	$22,022	$23,841	$5,085	$5,149	($6)	($6)	$5,079	$5,143
2022	$22,924	$24,768	($27)	($29)	$22,897	$24,739	$5,272	$5,334	($6)	($6)	$5,266	$5,328
2023	$23,851	$25,717	($28)	($30)	$23,824	$25,687	$5,469	$5,529	($6)	($6)	$5,463	$5,523
2024	$24,827	$26,715	($29)	($31)	$24,798	$26,683	$5,675	$5,733	($7)	($7)	$5,669	$5,727
2025	$25,844	$27,751	($30)	($32)	$25,814	$27,719	$5,889	$5,945	($7)	($7)	$5,882	$5,938
2026	$26,912	$28,838	($31)	($34)	$26,880	$28,805	$6,113	$6,166	($7)	($7)	$6,106	$6,159
2027	$28,045	$29,990	($33)	($35)	$28,012	$29,955	$6,349	$6,400	($7)	($7)	$6,342	$6,392
2028	$29,234	$31,195	($34)	($36)	$29,200	$31,159	$6,596	$6,643	($8)	($8)	$6,588	$6,635
2029	$30,481	$32,457	($36)	($38)	$30,446	$32,419	$6,853	$6,897	($8)	($8)	$6,845	$6,889
2030	$31,790	$33,778	($37)	($39)	$31,753	$33,739	$7,122	$7,162	($8)	($8)	$7,114	$7,154

WORKING DRAFT

Regional Toll Revenue Feasibility Study

Prepared for:
Washington State Department of Transportation
Urban Corridors Office

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Washington State
Department of Transportation

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DISCLAIMER

This Report was prepared by Parsons Brinckerhoff (PB), in accordance with an agreement with the Washington State Department of Transportation (WSDOT). This Report is subject to the terms and conditions contained within the consulting agreement, and is meant to be read as a whole and in conjunction with this disclaimer. It is one of several reports dealing with roadway pricing and was developed to support current regional discussions on transportation funding.

The Report, information contained herein, and any statements contained within the Report, are all based upon information provided to PB by, and obtained from, the Washington State Department of Transportation (WSDOT), the Puget Sound Regional Council (PSRC), and other sources. PB makes and provides no assurance as to the accuracy of any such information or any conclusions that are based thereon, and bears no responsibility for the results of any actions taken on the basis of this Report. This report does not constitute a recommendation of the WSDOT or PB.

This Toll Feasibility Study was prepared using the best available information and tools at the time of writing; however, the timing is such that this report does not benefit from work-in-progress refinements to the PSRC model, which when completed, will make the model better suited to toll modeling. In addition, other factors may have changed since the time this report was prepared. Specifications regarding the characteristics of the proposed toll facilities were developed in collaboration with WSDOT, and may or may not represent most likely scenarios for sections with proposed capital improvements and/or their construction phasing.

The traffic and revenue results presented herein are provided for feasibility considerations and to enlighten further policy discussions, and should not be construed as investment-grade projections. Better tools would need to be developed and applied with rigorous methods including independent review of assumptions at every stage to produce investment-grade projections suitable for securing a credit rating and obtaining toll revenue bond financing.

In the preparation of this Report and the opinions contained herein, PB makes certain assumptions with respect to such conditions that may exist or events that may occur that are subject to change in the future. These assumptions are made for purposes of modeling regional tolls and identifying a range of potential revenue, and are not intended to reflect any official decisions regarding new highway capacity investments. Although PB believes these assumptions to be reasonable for the purposes of this Report at the time of writing, they are dependent upon future events, and actual conditions may differ from those assumed.

EXECUTIVE SUMMARY

The Puget Sound Region's transportation needs far outstrip available funding, and increasing traffic congestion is adversely impacting our region's livability. This has led to a heightened call for new revenue sources to finance transportation infrastructure. User fees in the form of tolls have been a key element of this discussion, especially for the region's large scale "mega-projects". Technological advances in the area of electronic toll collection (ETC) has made roadway pricing more feasible by facilitating variable pricing to manage congestion and eliminating the traffic bottlenecks and land requirements of toll plazas. Tolling also has a key advantage over other transportation funding sources, in that it creates a direct linkage between project financing and those who use the roadway. And unlike a gas tax, the price of roadway use can be varied by roadway, time of day, type of vehicle, and even vehicle occupancy. Given sufficient autonomy in setting prices, a toll road owner/operator has the unique ability to manage traffic flows, prevent congestion, and thus, assure the traveling public of an efficient and reliable route.

Previous toll discussions have centered around the traffic and revenue impacts of tolling a single facility — either from a managed lanes approach whereby HOV lanes or new capacity is priced, or as the entire roadway. In either event, relatively little attention has been placed on the impact to other alternative highway routes. However, the traffic participation and resulting revenue arising from one tolled route is related to whether or not adjacent or alternative routes are also priced.

Two natural questions arise from this line of thinking:

(1) What happens to traffic demand on each facility if you toll all of the major highways within a given regional area; and

(2) What is the approximate range of potential toll revenue from a system-wide tolling of major facilities?

To help answer these questions and provide decision-makers with better information regarding the toll revenue potential from widespread highway pricing, this Regional Toll Revenue Feasibility Study was commissioned by WSDOT. Key findings of this study are presented on pages 12 and 13.

Study Objectives and Methods

The objective of this study is to model a regional toll highway network, including those facilities slated for "mega-project" capital improvements, in order to identify the potential range of revenue that might result from widespread value pricing to manage congestion. ***Policy issues regarding the tolling of existing federally funded interstate highways, toll restrictions of Senate Bill 6140, as well as the technological and administrative aspects of roadway pricing, including operational and maintenance costs, are not addressed in this study.*** The resulting revenue projections are intended to inform the policy discussion and assist decision-makers in determining if tolling has sufficient revenue potential and/or is an appropriate congestion management tool to merit further research, modeling and analysis.

For purposes of this regional pricing exercise, the introduction of tolls on a system of 131 miles of limited access highways in King and South Snohomish Counties extends to portions of seven facilities as listed in Table 1 and graphically depicted in Figure 1. Five of the seven facilities are proposed for various capital improvements, including:

- Replacement the earthquake damaged SR-99 Alaskan Way Viaduct;
- Completion of the south extension of SR-509;
- Capacity improvements to I-405 and SR-167; and
- Replacement of SR-520 bridge and connecting roadway improvements.

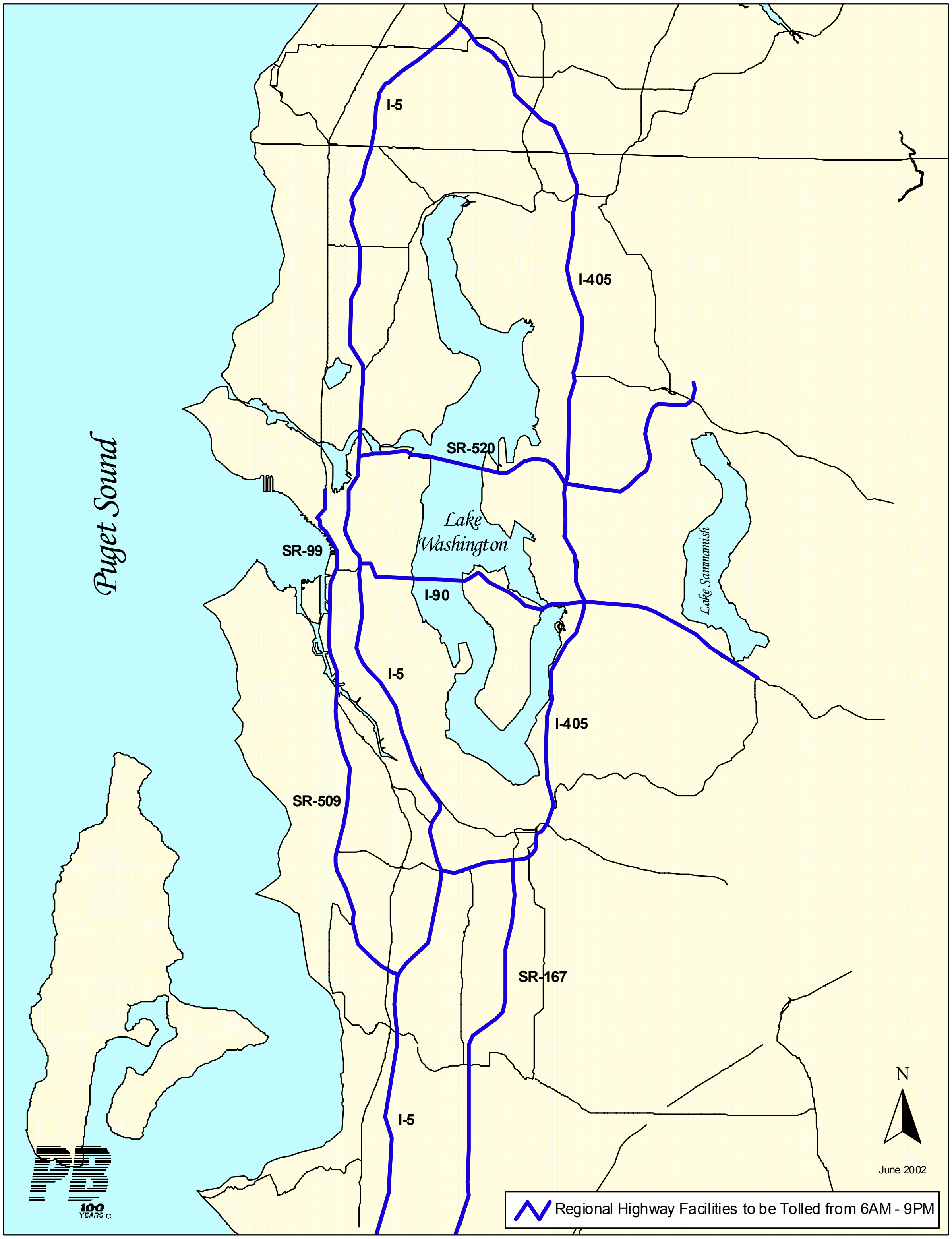
Only I-5 and I-90 are not being considered for major capital investments within the toll network boundaries; however, they will benefit from the other improvements, and to properly consider a balanced regional approach to value pricing and the best use of available highway capacity, they have been included in the toll network. It should also be noted that a limited access extension of SR-99 from Spokane Street south to the First Avenue South bridge and connecting with SR-509 was also included in the future network modeled. The assumed year of completion of the toll network and full implementation of tolling is 2014.

Table 1
Regional Toll Network Facilities

Toll Facility	*Extent of Tolling (North to South)*	*Toll Distance (miles)*
SR-99 / AWV	Roy St. to 1st Ave S.	6.1
SR-509	1st Ave S to I-5 at SR-516 I/C	11.8
I-5	North I-405 I/C to Pierce Co.	43.1
I-405	Entire Length	30.2
SR-167	I-405 to Pierce Co.	14.1
I-90	I-5 to SR-900	13.3
SR-520	Entire Length	12.8

The Puget Sound Regional Council's regional travel demand model and forecasting procedures were adapted for analyzing the regional toll network. While these tools represent best-practice methods for feasibility purposes currently available, this work is at the edge of their intended application, and moreover, the timing is such that this work does not benefit from work-in-progress improvements to the regional model.

Figure 1
Regional Toll Network as Modeled



In theory, the mechanism by which tolls are simulated within the regional model is relatively simple. On an un-priced roadway, users consider only their own travel time costs, and not the delay costs their vehicle imposes on other users. This behavior tends to result in roadway over-consumption and congestion, especially during peak demand times. Optimal travel behavior — that which theoretically minimizes overall network travel time — could be induced by applying tolls that are equivalent to the incremental delay imposed on others, with the revenues used to make cost-beneficial transportation investments. This is referred to as the "economically efficient" toll.

The modeling approach employed seeks to internalize the external time cost or incremental delay that an additional vehicle imposes on all other vehicles in the traffic stream. When users are compelled to consider this additional cost, some users alter their travel behavior, resulting in lower highway volumes, and higher resulting speeds. As roadway demand increases, the economically efficient or optimal toll also rises at an increasing rate to maintain reasonable speed and flow conditions, by inducing a sufficient number of would-be road users to seek alternative routes, modes, or times to travel.

Optimal Toll Rates

Optimal toll rates, expressed as time costs (minutes per mile), are derived from the model outputs for 46 analysis segments within the 131-mile regional toll network by two directions of travel and three daily time periods (AM peak, PM peak, and midday/evening off-peak) totaling 15 hours. These toll time costs are then converted to monetary rates by applying the average willingness to pay for delay reduction, expressed in dollars per hour. Research has shown that this value of time is approximately one-half of the average wage rate. For purposes of this study, the value of time was varied between one-third and one-half of the average wage rate for King County to create a range of monetary toll rates.

Table 2 presents the range of optimal toll rates per mile, by time period and facility, for the base and low values of time in 2014, the proposed year of full implementation. The toll rates are expressed in 2014 dollars and apply to single and two occupant vehicles. With few exceptions, transit and three-plus occupant vehicles are assumed to use toll-free HOV lanes at no charge or would otherwise be exempted from tolls. Trucks are tolled at a multiplier of the auto toll rates.

Table 2
Toll Rate Spectrum for 2014 in Inflated Dollars (Base Value of Time)

Toll Facility	Toll Distance	PM Peak Period — $ / mi			AM Peak Period — $ / mi			Off-Peak / Weekend — $ / mi		
		Minimum	Maximum	Average	Minimum	Maximum	Average	Minimum	Maximum	Average
SR-99	6.1	$0.04	$0.22	$0.11	$0.04	$0.22	$0.11	$0.04	$0.04	$0.04
SR-509	11.8	$0.04	$0.14	$0.09	$0.04	$0.14	$0.09	$0.04	$0.04	$0.04
I-5	43.1	$0.04	$0.33	$0.14	$0.04	$0.21	$0.10	$0.04	$0.05	$0.04
I-405	30.2	$0.04	$0.19	$0.11	$0.04	$0.11	$0.07	$0.04	$0.04	$0.04
SR-167	14.1	$0.04	$0.20	$0.12	$0.04	$0.15	$0.09	$0.04	$0.04	$0.04
I-90	13.3	$0.04	$0.25	$0.13	$0.04	$0.18	$0.08	$0.04	$0.04	$0.04
SR-520	12.8	$0.06	$0.42	$0.19	$0.04	$0.28	$0.12	$0.04	$0.07	$0.05
Network	**131.3**	**$0.04**	**$0.42**	**$0.13**	**$0.04**	**$0.28**	**$0.09**	**$0.04**	**$0.07**	**$0.04**

Note: All amounts in year of collection dollars

Tolls are assumed to be levied electronically throughout the regional toll network. The AM and PM peak periods would vary in timing and duration by facility and location, but in no cases are less than three hours. Peak period toll rates range from 4¢ per mile to 42¢ per mile, with an average rate of 13¢ per mile in the PM peak and 9¢ per mile in the AM peak. Peak toll rates would vary noticeably by facility conditions, levels of congestion, and location to remain at their optimal levels. With reduced facility demand, the off-peak toll rates are generally lower, with an average toll of about 4¢ per mile. Off-peak tolls would apply to a midday window of time on weekdays, weekday evenings from 7 – 9 PM, and weekends from 6 AM – 9 PM. The network was assumed to be toll-free every day from 9 PM – 6 AM, both to give users an un-priced choice of travel, and also because, in most cases, traffic volumes are not high enough to generate optimal toll rates much above zero.

Toll Diversion Impacts

Application of the toll modeling methodology within the PSRC regional model results in lower vehicular traffic forecasts within the tolled general purpose lanes (excluding transit vehicles and 3+ HOVs).

Compared with the toll-free case, introduction of optimal tolls on a system of limited access highways in King and South Snohomish Counties will result in the diversion of some vehicle trips away from these facilities during the toll periods. These diverted trips fall into several categories:

- Travelers who make the same trip but divert to an alternate, un-priced route, usually another highway or arterial street;
- Travelers who continue to make the same trip on the tolled facility using their private vehicle, but traveling at a different time of day, when there would be a lower toll rate;
- Travelers who continue to make the same trip at the same time of day, but who will now travel in a vehicle that can use toll-free HOV lanes , either in a high occupancy vehicle with three or more occupants or in a bus;
- Travelers who will choose to change their trip behavior, either traveling to a different destination, such as one in a different direction that they can get to without using a tolled highway, or one nearer to their origin so that the shorter distance results in a lower toll charge to get there; and
- Travelers who opt to eliminate trips, either by not traveling at all, or by combining the functions of two or more trips into a single trip.

The average model diversion rates by facility due to the optimal tolls are shown in Table 3. Actual diversions rates vary somewhat by location, time of day and direction of travel for each facility. Note that diversion rates apply only to non-HOV travel; the actual change in highway traffic volumes is somewhat less due to some of the diverted vehicles converting to 3+ HOVs.

Note that the relatively low diversion rates for I-90 reflect the excess capacity and superior travel conditions of this facility relative to the SR-520 alternative, as well as the lack of alternatives for Mercer Island residents.

Table 3
Average Toll Diversion Rates by Facility (15-Hour Toll Period)

Toll Facility	Toll Distance	Rates of Diversion 2014	2020	2025	2030
SR-99	6.1	-11.8%	-12.1%	-12.4%	-12.7%
SR-509	11.8	-17.4%	-17.4%	-17.4%	-17.5%
I-5	43.1	-17.9%	-18.6%	-19.1%	-19.7%
I-405	30.2	-16.1%	-17.2%	-18.1%	-19.0%
SR-167	14.1	-18.0%	-18.4%	-18.6%	-18.9%
I-90	13.3	-6.4%	-6.4%	-6.4%	-6.4%
SR-520	12.8	-17.4%	-17.8%	-18.2%	-18.5%
Network	**131.3**	**-16.1%**	**-16.8%**	**-17.3%**	**-17.9%**

By way of comparison, a retroactive look at the SR-520 Evergreen Point Floating Bridge prior to eliminating the $0.35 toll in 1979 indicates that 16.2% of the post-toll traffic level was being diverted by the toll, with a little more than one-third of the diverted vehicles using I-90, and the remainder choosing other routes or not traveling at all. Incidentally, the $0.35 one-way toll on the SR-520 toll bridge when it opened in 1963 is equivalent to a $2.30 toll in 2014. The same toll, unchanged when removed in 1979, equates to $1.14 in 2014 dollars. By comparison, the model's average PM-peak toll rate for SR-520 is $0.19 per mile (Table 2), which equates to a toll charge of $1.34 for travel between I-5 and I-405. Average modeled toll rates and travel costs at other times of day are lower. This suggests that the regional toll modeling results for SR-520 are within the bounds of the historical SR-520 bridge toll rates when expressed in the same year's dollars.

The model processes for determining diversion, interpretation of the resulting diversion rates, and the impacts on the arterial system warrant further research and analysis. The regional travel demand model does an adequate job of estimating the overall levels of diversion, but it is less able to provide reasonable estimates of what would become of the diverted vehicles, particularly for diversion to arterial streets. The model is most able to estimate diversions to other routes and modes, and is least able to estimate diversions to other time periods or eliminations of trips.[1] Moreover, the model may not sufficiently discourage arterial street use as an alternative to a tolled highway as the arterials get congested. All of these factors suggest diversion may be over-estimated, which would result in both underestimated optimal toll rates and toll facility traffic volumes — both of which would tend to underestimate the revenue yield.

Nonetheless, examining the 2030 traffic forecast with and without tolls indicates that, at least on a daily basis, total vehicle miles traveled on the arterial system would not increase with the presence of tolls on the limited access facilities. However, there are bound to be individual arterial segments that would undoubtedly be loaded with increased traffic at certain times.

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[1] Overall network demand remains relatively fixed in the regional model, which may not be a reasonable if trips are eliminated.

Revenue Projections and Considerations

The model-derived optimal toll rates were applied to the toll traffic volumes, expressed as vehicle miles traveled by analysis segment, to generated weekday revenue projections by direction and time period. A series of adjustments and factors were then applied to yield annual traffic projections. These include weekday-to-weekend day factors, weekday and weekend truck percentages to facilitate trucks paying a multiplier of the auto toll, and a five percent reduction to the overall volumes to reflect the potential for lost revenue from electronic toll collection (ETC) non-participation and/or evasion.

As shown in Table 4, a range of toll revenues were projected for the regional toll network from the year of implementation (2014) through the model forecast horizon (2030).[2] These forecasts represent potential gross revenues before any operations, maintenance and administration costs. The "high end" of the revenue spectrum is determined using the base value of time to derive the optimal toll rates, combined with the assumptions of weekend tolling at the off-peak toll rates and the tolling of trucks at an average toll rate of three times that paid by passenger vehicles. In this case, the term "high end" represents the top of the regional tolling revenue range for the given assumptions under the economically efficient toll methodology; it is not meant to convey the point of revenue maximization, and is in all likelihood below this point. The "low end" of the spectrum applies conservative assumptions, including the low value of time, an average truck toll rate of two times the auto rate, and no tolling on weekends.

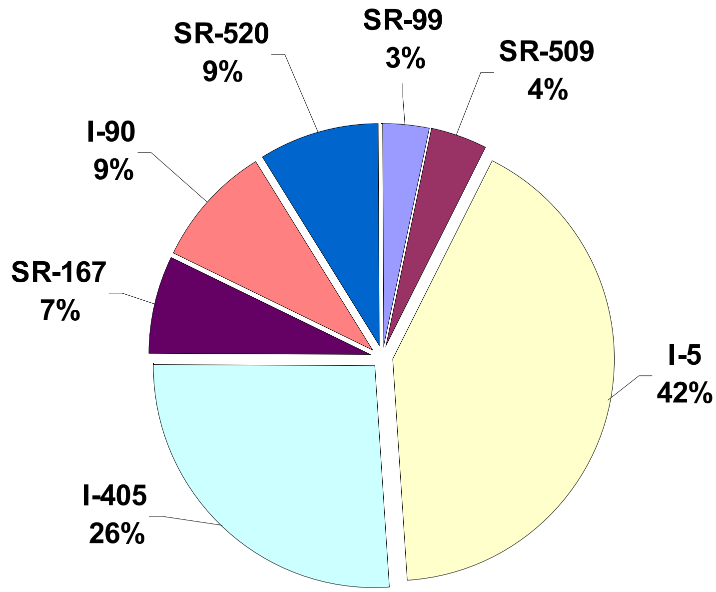
Table 4
2014 Projected Regional Toll Revenue Range in Inflated Dollars

Toll Facility	*Toll Distance*	*2014 Revenue Range in Inflated Dollars*	
		LOW END: Low Value of Time Weekends Toll-Free 2x Truck Toll Factor	*HIGH END: Base Value of Time Weekend Tolling 3x Truck Toll Factor*
SR-99	6.1	$8.5 M	$14.8 M
SR-509	11.8	$11.5 M	$20.1 M
I-5	43.1	$102.8 M	$189.2 M
I-405	30.2	$64.4 M	$119.0 M
SR-167	14.1	$17.9 M	$32.5 M
I-90	13.3	$24.1 M	$41.8 M
SR-520	12.8	$23.0 M	$40.0 M
Network	**131.3**	**$252.1 M**	**$457.3 M**

[2] For purposes of this exercise, it is assumed that all of the proposed network improvements, including a not yet contemplated limited access connection between the Alaskan Way Viaduct and SR-509, would be in place by 2014.

Figure 2 presents each facility's contribution to the regional toll revenue projection. It is important to note that each toll facility's revenue result would change, perhaps even substantially, if one or more of the proposed toll facilities were not priced.

Figure 2
2014 Distribution of Regional Toll Revenue by Facility

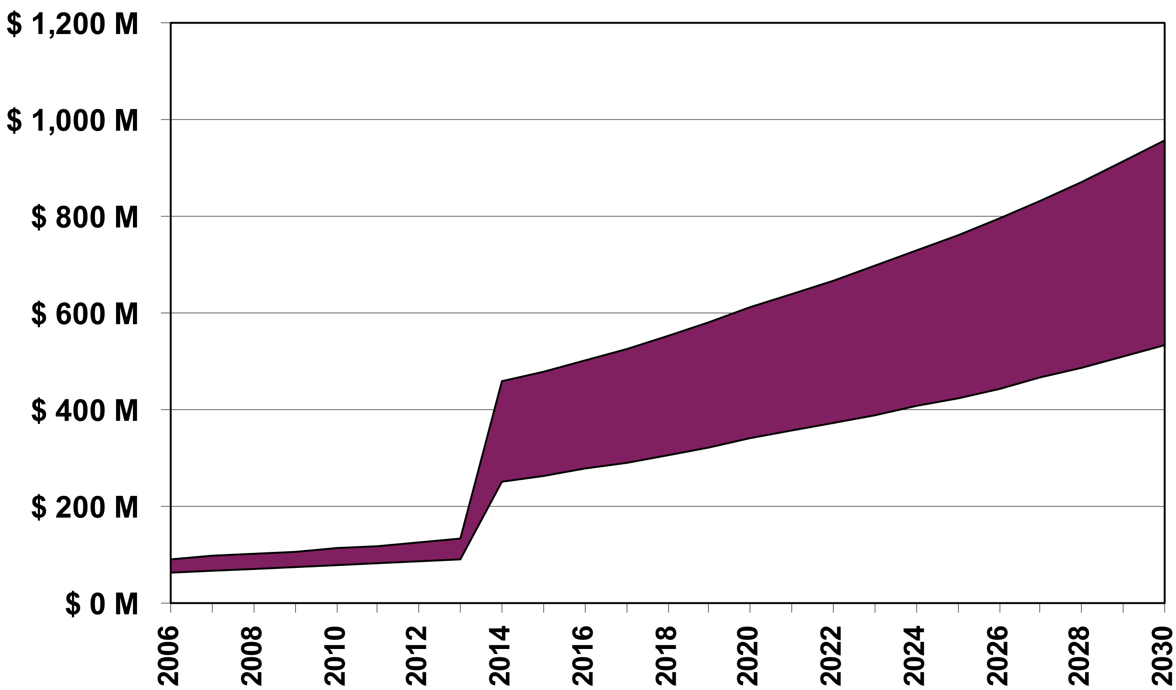


In addition, cursory consideration was given to the toll revenue that might be possible during a seven year implementation period from 2006 – 2013, as the proposed improvements are being put into service and toll usage is ramping up. In the absence of detailed information regarding project phasing and construction impacts, not to mention resources for the extensive additional modeling efforts had such information been available, a simplified partial revenue approach was adopted. In effect, toll revenues from 2006 – 2013 were estimated for the entire toll network using the off-peak toll rates, which are sub-optimal for the peak periods. This gives a revenue range of between $63 and 91 million in 2006, growing to between $91 and 132 million by 2013. In reality, if tolls were uniformly applied to the regional network during this period, the reduced capacity of those facilities undergoing construction could actually lead to higher real toll rates and lower highway traffic volumes than would be observed once the improvement projects were completed. However, there may be resistance to implementing the full optimal toll rates prior to completing the various network improvements.

It is interesting to note that the 2013 partial revenue method yields a result that approaches the I-5 contribution to the regional total revenue (shown in Table 4 for 2014). However, if I-5 were tolled singularly, it is likely that it would generate less revenue than as part of a regional system, although additional modeling work would be required to verify a range for this differential. Nonetheless, the simplified revenue estimate for 2006 – 2013 may be a rough proxy for implementing tolls on I-5 at the outset of construction through 2013. This might be a reasonable first option, especially for managing congestion on I-5, since although construction will be directed elsewhere, construction impacts on the other facilities, especially I-405, SR-99 and SR-509 would definitely cause diversion to, and thus worsened congestion on I-5.

Figure 3 presents the projected range of regional toll revenue from 2006 through 2030 in inflated, year of collection dollars.

Figure 3
2006-2030 Regional Toll Revenue Forecast Range in Inflated Dollars



Note that nominal annual revenue is shown growing at an increasing rate over time. This reflects both growing demand and a rising set of optimal toll rates on the regional facilities, the latter which are assumed to escalate for two reasons:

1. Growth in traffic demand will necessitate an increasingly higher optimal toll in order to elicit the appropriate travel behavior changes and diversion to maintain economically efficient network travel conditions and speeds; and

2. Over time, general inflation will increase the average wage rate, and thus users' value of time, the latter of which drives the calculation of the optimal toll rate to keep up with inflation.

This is an important outcome, and one that may prove challenging due to public resistance even after tolling is implemented. Failure to increase optimal toll rates for both value of time inflation and rising demand, particularly during peak periods, would eventually lead to the recurrence of congestion. Moreover, because value of time is variable, and may on the margin increase substantially over average values, it may be advisable to craft toll enabling legislation in such a way that allows the toll authority to set the lowest toll that keeps speeds no lower than some threshold. The value for this threshold would be determined in advance based upon the facility characteristics and desired operating objectives.

The methods employed provide ranges for economically efficient or optimal tolls that attempt to minimize overall network travel times, which generally result in toll rates below those that maximize revenue, but above those that pack the facilities for maximum vehicle throughput. However, these methods do not indicate where in this spectrum the modeled toll rates lie, nor do they give any indication of the elasticity of demand. As such, there is no way to pin down how much demand and revenue will change if the optimal toll rates are altered. Indeed, a much more comprehensive modeling effort, involving substantial market survey research and independent review of all modeling assumptions, would be required produce investment-grade toll traffic and revenue forecasts.[3] Nonetheless, the resulting range of annual revenues likely encases some portion of the true revenue potential, and can thus help decision makers ascertain if additional, more resource-intensive market research and modeling make sense.

Summary of Findings

- Travel levels on the highway network of King and South Snohomish Counties have reached critical levels relative to available capacity to make value pricing of this capacity a viable method to manage demand to prevent congestion and generate new revenue to fund transportation improvements.
  - Seven major highways in King and South Snohomish County totaling 131 miles were modeled as toll facilities for this study. This regional toll network differs from that included in Regional Transportation Improvement District (RTID) proposed by the County Executives of King, Snohomish, and Pierce Counties. Additional context information about the County Executives' proposal is included in the main report.
- Simulating tolls in the regional travel demand model for seven major highway facilities yields optimal toll rates that seek to *minimize overall network travel time* with the objective of economic efficiency. These toll rates are higher than those which would *maximize facility throughput* but lower than those which would *maximize toll revenue*.
  - The maximum throughput objective may sound appealing, but would likely be sub-optimal not only from a revenue standpoint, but also because it would spend more of the public's time at a higher total social cost to get the maximum number vehicles through than would result with a higher toll rate.
  - There may be cause to set tolls closer to revenue maximizing levels if other tolling objectives do not generate sufficient revenue to support the improvement expenditures.
- In the assumed year of implementation (2014), these toll rates range from 4¢ to 42¢ per mile in year of collection dollars, depending on the location, time of day and travel direction.
  - Peak period toll rates would typically average around 11¢ per mile, whereas off-peak toll rates would hover about 4¢ per mile.
  - The optimal toll rates will need to increase periodically due to both inflation and growing travel demand, if the roadway is to be managed to maintain optimal network results and avoid congested conditions. These toll increases will require that the

[3] For more information, see the Next Steps section of the main report.

operating objectives and management policies of the facility be well established and clearly communicated to the public and policy-makers. It may be useful to craft toll enabling legislation to allow the toll authority to set toll rates at the minimum levels designed to maintain a certain speed threshold.

- At the time of writing, general tolling of federally funded interstate highways is highly restricted. Implementation of any regional tolling concept would likely require that these restrictions be relaxed. There is some indication that this may occur in the next federal transportation funding authorization act.
- For 2014, the projected toll revenue is estimated to range from approximately $252 to $457 million per year in inflated dollars, depending on the underlying value of time assumption and various operating parameters, and before operating and maintenance expenses. This estimated annual range is expected to grow to between $535 and $955 million by 2030 assuming tolls escalate with demand growth and inflation.
  - The top end of this range applies the base value of time ($11.83 per hour), includes weekend tolling, and tolls trucks at an average rate of three times the auto toll, but does not represent the revenue maximizing situation. The assumptions underlying the top end of this range are not overly optimistic.
  - The bottom end of this range applies the low value of time ($7.89 per hour), excludes tolls on weekends, and toll trucks at an average rate of two times the auto toll. The assumptions underlying the bottom end of this range are fairly conservative.
- Implementation of tolls will cause travel demand on these facilities to decrease as those users whose cost of travel in time plus tolls exceeds the benefits from travel seek other options.
  - Some users will divert to other un-priced alternative routes, lower cost times of travel, closer destinations or lower cost modes (HOVs and transit). Others will eliminate their trips altogether or combine trips.
  - The model results may over-estimate the true diversion away from the toll facilities, which would tend to understate the optimal toll rates and toll revenue potential. Further research and model refinements would be needed to better understand diversion impacts, especially to the arterial street system.
- Additional policy and institution factors that need further consideration:
  - Potential diversion impacts to the arterial street network needs further study, including a detailed analysis of how diversion impacts arterials and consideration of local jurisdiction concerns and priorities.
  - Policy and legal issues regarding the tolling of existing facilities, be they interstate highways funded with federal dollars or facilities that do not receive improvements, need to be considered in the context of the interdependence of a regional toll network.
  - Further study of the technological and economic feasibility of implementing wide-spread electronic toll collection, including capital investment costs and ongoing operating, maintenance and administrative expenses, needs to be undertaken.
  - A detailed financial analysis is needed to gauge the appropriate capacity of the projected revenue stream for financing the system of proposed projects and related improvements.

INTRODUCTION

This report is part of a series of efforts to examine funding for regional highway capacity improvements. User fees in the form of tolls are receiving wide-spread discussion as a potential source of funding for at least four regional mega-projects — SR-99 Alaskan Way Viaduct replacement, SR-509 south extension, Trans-Lake Washington (SR-520) improvements and I-405 widening (including widening a portion of SR-167). The objective of this study is to enlighten this discussion and policy decision process regarding tolls by examining the traffic and revenue impacts of region-wide tolling. Specifically, the above four facilities slated for mega-project capital investments, combined with sections of SR-167, I-5 and I-90, have been modeled as toll facilities to assess the maximum revenue potential of roadway pricing. The intent is to help place the high book-end for revenue represented by a systems approach to tolling — both to add perspective to ongoing toll discussions, and to assist decision-makers in determining if roadway pricing could have sufficient revenue potential and/or is an appropriate congestion management tool to warrant further research, modeling and analysis on a more selected basis.

Recent advances in tolling technology, efficiency and acceptability have made roadway pricing a viable means to finance a broader range of transportation improvements. From a policy and management standpoint, the implementation of roadway pricing, along with sufficient autonomy to set toll rates, would give the Washington State Department of Transportation the capability to manage congestion and assure the traveling public that the priced facilities will always operate in a free-flow manner. While tolls may not be popular with everyone, they tend to be accepted as an efficient way to finance portions of transportation infrastructure by connecting part of the costs directly to those who use the facilities. In addition, technological advances in the area of electronic toll collection (ETC) has made roadway pricing more feasible by facilitating variable pricing to manage congestion and eliminating the traffic bottlenecks and land requirements of toll plazas.

Moreover, in this era of accountability in government, providers of new transportation infrastructure have a responsibility to the public to manage those resources in a socially efficient manner. The gridlock that has become ubiquitous on unmanaged facilities during peak times is predictably inefficient and imposes tremendous delay costs that increase the prices of goods and services and lower the quality of life for everyone. As demand continues to swell, additional management techniques including pricing need to be applied to help alleviate congestion, or at least mitigate growth to prevent the situation from worsening.

The following applies a relatively simple and efficient methodology for modeling regional highways as a toll facilities, taking into account future travel demands and users' willingness to pay for a facility that provides travel time savings and reliable commute times. It is intended to enlighten the discussion of how tolls might be used in these corridors and assess the revenue potential of implementing an optimal or economically efficient toll structure. And while the revenue forecast ranges offered are adequately precise to inform the decision process as to whether tolls make good technical and political sense, they are not purported to be sufficiently accurate to secure debt financing from the financial markets.

In considering the implementation of user fees in any corridor, it is important to keep in mind that there is a spectrum of operating objectives that can lead to a wide range of pricing strategies. Toll facilities may be operated to maximize revenue, to achieve a revenue target (perhaps linked to debt service and/or operating costs), to maximize travel benefits by minimizing overall network travel times, to maximize throughput of an individual facility, or to keep vehicle throughput within a target range. Minimization of network travel times (economic efficiency) and revenue maximization objectives may suggest varying toll rates by time of day, direction, and/or travel distance, whereas a revenue target may be achievable with a relatively simple toll structure. And just as different operating objectives suggest different toll structures, so to does the availability and quality of alternate routes. The more a priced facility reduces delay and provides a reliable, efficient transportation connection over other alternatives, the greater the willingness to pay by the traveling public.

Following the Executive Summary and this Introduction are five main sections — Methodology, Traffic and Toll Revenue Forecasts; Related Studies and Toll Facility Information, Next Steps, and Key Findings. A bibliography and an appendix are also provided.

METHODOLOGY

The toll modeling approach herein relies on the Puget Sound Regional Council's (PSRC) regional travel demand model. The PSRC model is a traditional four-step travel demand model that has undergone continuous refinement over the past two decades. At present, the model incorporates the base year and 2030 land use forecasts from the 2030 Metropolitan Transportation Plan (MTP) adopted by the PSRC in May 2001.

The existing PSRC model was previously refined for application to the Alaskan Way Viaduct (AWV) and Trans-Lake Washington projects.[4] This version of the PSRC model was further modified to incorporate specially developed procedures that were used to simulate and test the viability of tolling on highway facilities. In order to model region-wide tolling with the completion of the four mega-projects, a future network reflecting these improvements was coded into this version of the model. Table 5 on the following page summarizes the relevant facility network assumptions used in model coding as well as other relevant items, including extent of tolling, hours of tolling, and HOV/transit assumptions.

The approach for toll traffic and revenue modeling described herein represents a balance between the best theoretical technical methods, which are extremely resource and time-intensive to execute, and real world constraints regarding currently available tools and information, the early stage of the proposed projects, and a short timeline — all of which dictate a more pragmatic approach. Given a specific aim to determine the range of toll revenue that might be possible with widespread pricing to provide perspective and facilitate discussion — as opposed to developing resource-intensive "investment grade" toll revenue forecasts for purposes of securing financing from the bond market — this compromise approach strikes a reasonable balance. The results of this study should help to enlighten the ongoing policy discussion of user fees within the region, and to a lesser extent, on individual facilities, which may set the stage for further investigation and model refinement using more rigorous methods and their commensurate cost.

[4] See the Travel Forecasting Model Validation Report for Base Year 1998 prepared for WSDOT by PB, February 2002

Table 5
Future Network Modeling Assumptions

Attribute	*SR-99*	*SR-509*	*SR-520*	*I-90*	*I-405 (incl. SR-167)*	*I-5*
Alternative Modeled	Alternative D + limited access extension to SR-509	Preferred Alternative	6-Lane	Existing (No New HOV lanes)	Preferred Alternative	Existing + Committed HOV
# GP Lanes + # HOV Lanes per Direction	3 (including SR-509 to Spokane St extension)	2 + 1 (existing & new segments)	2 + 1	~3 + 1 (varies)	~4 + 1 (varies)	~4 + 1 (varies) 2 + 1 (express lanes)
HOV Lane Eligibility	No HOV Lane	HOV 3+ & Transit only	HOV 3+ & Transit only	HOV 3+ & Transit only	HOV 3+ & Transit only	HOV 3+ & Transit only
Toll Exemptions	Transit Vehicles Exempt	HOV 3+ and Transit (HOV Lane Toll-exempt in Model)	HOV 3+ and Transit (HOV Lane Exempted in Model)	HOV 3+ and Transit (HOV Lane Exempted in Model)	HOV 3+ and Transit (HOV Lane Exempted in Model)	HOV 3+ and Transit (HOV Lane Exempted in Model)
Extent of Tolling (South to North or West to East)	SR-509 to Roy St.	SR-516 to SR-99	I-5 to Redmond (SR-202)	I-5 to Issaquah (SR-900)	Tukwila (I-5) to Lynnwood (I-5) plus SR-167 to County Line	King / Pierce Co. Line to Lynnwood (I-405)
Hours / Days of Tolling	6 AM to 9 PM weekdays & weekends	6 AM to 9 PM weekdays & weekends	6 AM to 9 PM weekdays & weekends	6 AM to 9 PM weekdays & weekends	6 AM to 9 PM weekdays & weekends	6 AM to 9 PM weekdays & weekends
Trucks (all sizes)	Assumed to Pay a Multiplier of the Relevant Auto Toll Rate by Time Period					
Transit Service	Sound Transit Phase I + 1% Annual Growth in Bus Service					

The Puget Sound Regional Council (PSRC) approach to modeling tolls was developed by an outside consultant as part of a congestion pricing analysis for the 2030 MTP process. It simulates congestion pricing (tolling to manage flow) within the existing regional modeling framework. Specifically, it approximates the optimal "economically efficient" toll in such a manner that does not require significant market research regarding user demographics and preferences, and without having to re-specify the mode choice components of the model.

In order to fully understand this approach and the interpretation of the economically efficient toll, it is useful to consider the differences between various toll road operating objectives.

Toll Facility Operating Objectives

Differing operating objectives for toll facilities in the U.S. and abroad result in differing "optimal" toll rates or structures based upon the physical, technical and political characteristics of each situation. Four such recurring objectives considered in the modeling of toll facilities, which can at times be either compatible or conflicting, are:

1. Throughput maximization;
2. Revenue/profit maximization;
3. Revenue target (i.e., O&M cost plus debt service coverage); and
4. Economic efficiency in terms of congestion management.

Throughput maximization refers to a traffic engineering metric for an individual facility, measured in persons or vehicles per hour. This objective has a certain public appeal when considering the pricing of excess capacity in an HOV lane, the so-called High Occupancy Toll (HOT) lane approach. In a broader sense, this objective attempts to fully utilize the capacity of a facility by serving the most travelers possible. The assumption here is that in an un-priced situation, demand exceeds capacity such that severe congestion results, causing flow to breakdown. Pricing is thus required to maximize throughput and prevent unstable flow conditions. Maximum throughput occurs at the point just prior to flow breakdown, where a marginal increase in demand disrupts traffic flow, causing it to become unstable. For multi-lane freeway facilities, maximum throughput corresponds to traffic volumes that result in speeds of approximately 45 mph. Pricing or other demand management tools must be sufficiently precise and dynamic to prevent flow breakdown under this operating objective. In practice, this operating objective may require the use of a throughput target that approaches but falls short of maximum throughput to provide a sufficient margin of error against crossing over the line into unstable flow conditions. In addition, this objective will not result in an efficient balance between total travel time and cost, particularly when considering that a higher toll could improve travel times and provide more revenue to be re-invested into capacity improvements or other investments to benefit those who choose not to pay the tolls.

Revenue maximization, or **profit maximization**, which is a form of revenue maximization subject to a cost function, capitalizes on users' willingness to pay for the toll road's attributes — primarily time savings, as well as convenience, reliability/predictability, safety, etc. Tolls are set to maximize net revenue taking into account the relationship between travel time savings and willingness to pay, and only a fraction of all travelers during peak periods will choose to pay. If throughput maximization is at one end of the spectrum of toll rates and volumes, revenue maximization is at the other. The latter objective tends to result in tolls that are notably higher and facility volumes that are notably lower than throughput maximization, along with speeds that tend to be at or near free-flow (speed limit) conditions. However, these attributes lead to high rates of diversion to alternate routes, and overall network travel times will not be optimized.

The **revenue target** objective seeks to achieve a particular threshold, such as sufficient revenue to cover the toll facility's operating and maintenance costs (O&M) and ongoing debt service expenses by a reasonable margin, or alternatively to fund some other objective such as transit service in the same corridor. To the extent that the target is less than the maximum revenue attainable, this objective results in a lower toll rate, and thus a higher traffic volume than the revenue maximizing objective. Also, since debt payments are often fixed, and increasing O&M cost may be offset by growing traffic demand, this objective may be associated with toll rates that do not increase regularly with inflation.

The **economic efficiency** objective uses tolls to correct for the economic distortion or market imperfection that occurs with an un-priced highway facility, resulting in over-consumption of the roadway by users that do not fully perceive all marginal costs of their use. An individual user entering an un-priced roadway perceives only his or her own personal delay or time costs, and not the "external" impacts that his or her vehicle imposes on the traffic flow, despite the fact that this results in additional delay to other users. The latter impact on other travelers is an economic externality — a cost or benefit of a market transaction that is not reflected in the prices consumers and suppliers use to make their decisions. In this case, the market "transaction" is use of the road for travel, the consumer is the individual roadway user, the "price" is the individual's travel time or time cost for the road use, and the supplier is the road owner. Because a user's travel choices do not consider the incremental delay they impose on others, a negative externality results.

A price signal in the form of a toll can be used to get the user to recognize the delay they impose on others in making their own travel choices. Tolls are set to the levels that allow only those users whose benefits of travel equal or exceed the marginal costs of travel. In the short run, ignoring pricing issues for auto use, the marginal cost of vehicular travel is the sum of the private travel time cost for that vehicle plus the social delay cost it imposes on other vehicles. In other words, the efficient toll is defined as the one at which the user is paying a price that equals the true short-run marginal cost of travel. Since the user's private costs are "paid" in time, the actual monetary "efficient" toll rate for this objective is the amount that causes users to fully consider the social delay costs that their travel decisions impose on other users of the roadway.

On an uncrowded facility, the addition of another vehicle has a negligible effect on the travel time for the relatively few existing vehicles. With excess capacity, the external cost represented by the economically efficient toll is very low as delay externalities are too insignificant to matter. However, the external cost or incremental delay factor rises with volume and can become quite substantial as the facility approaches capacity, when its performance under congestion deteriorates rapidly with additional demand.

Assuming that users have perfect information about pricing, that toll revenues are used to make cost-beneficial highway investments, and that pricing is ubiquitous, then short-run marginal cost toll pricing allows the road network to operate with maximum net social benefits from the resources used to build and operate roads. In this case, the economically efficient toll rate **maximizes travel time savings**, which for a given volume of traffic, **minimizes total network travel time**.[5] In theory, toll rates resulting from the economic efficiency objective would lie somewhere between the revenue maximizing toll and the throughput maximizing toll.

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[5] Note that the proper measurement of total travel benefits includes the toll revenues since some of the time savings are captures by the tolling authority and returned to all users in the form of cost-beneficial highway investments.

In practice, this operating objective is difficult to measure and achieve, making it difficult to know where in the spectrum the estimated toll rate lies. Market imperfections, incomplete information, and less than ubiquitous tolling lead to sub-optimal behavior and increased diversion, and may result in toll rates that are higher than intended. Nonetheless, the more diversion opportunities are contained, and the more inelastic demand is (the more captive the user is, as would be the case during peak periods), the narrower the spectrum between the revenue maximizing and economically efficient toll rates.

Applying Tolls within the PSRC Regional Model

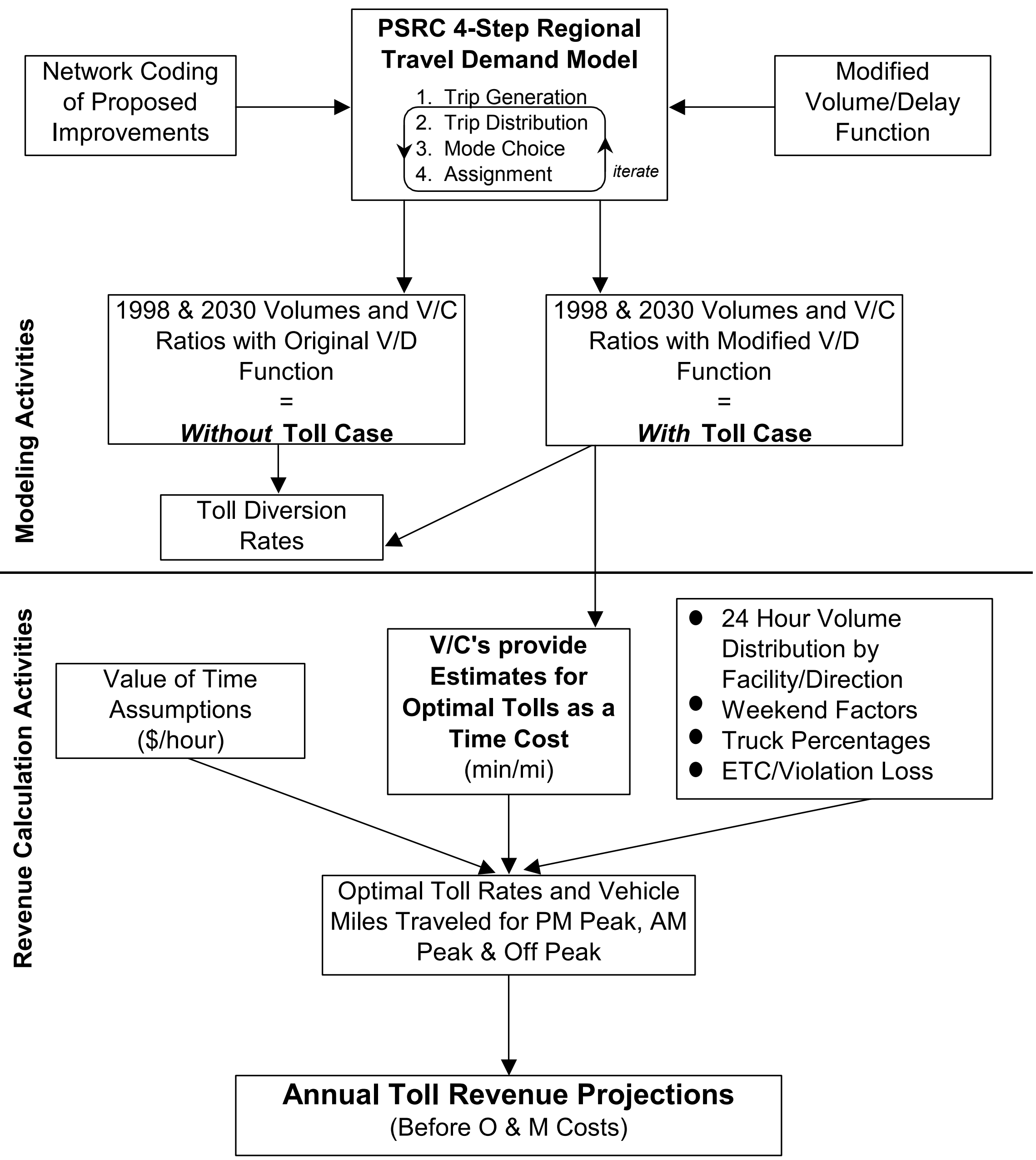
The PSRC approach for simulating tolls/congestion pricing within the regional travel demand modeling framework is theoretically equivalent to the fourth operating objective above , that of economic efficiency. In reaching equilibrium, the traditional four-step PSRC regional model attempts to minimize overall network travel times, subject to various constraints including an essentially fixed level of demand by analysis year. The same is true when tolls are added as an additional time cost or impedance to the network links that represent toll facilities. When demand is assumed to be relatively fixed, minimization of network travel times is equivalent to maximizing travel benefits (time savings), which is the objective of the economically efficient toll rate.

Roadway pricing is introduced by adding an impedance increment to travel times used in the regional model (in the form of a time cost that is convertible to a monetary toll) that brings the total impedance up to the level that reflects the true incremental impedance, rather than just the impedance perceived by each user. This is done by modifying the mathematical specification of the model's volume-delay function(s) to incorporate not only the "own" delay, but also the additional delay imposed on other vehicles on a link by link basis.[6] The greater impedance perceived on the toll links causes diversion to non-toll links by those users for which the additional toll time cost triggers total costs to exceed the toll facility's travel benefits, though actual travel times improve. It is important to note that within this application of the PSRC regional model, overall demand does not change in response to tolls; rather, the model redistributes demand in a different manner among alternative routes, which also results in some trips being shortened.

Figure 4 on the following page summarized the overall toll modeling methodology.

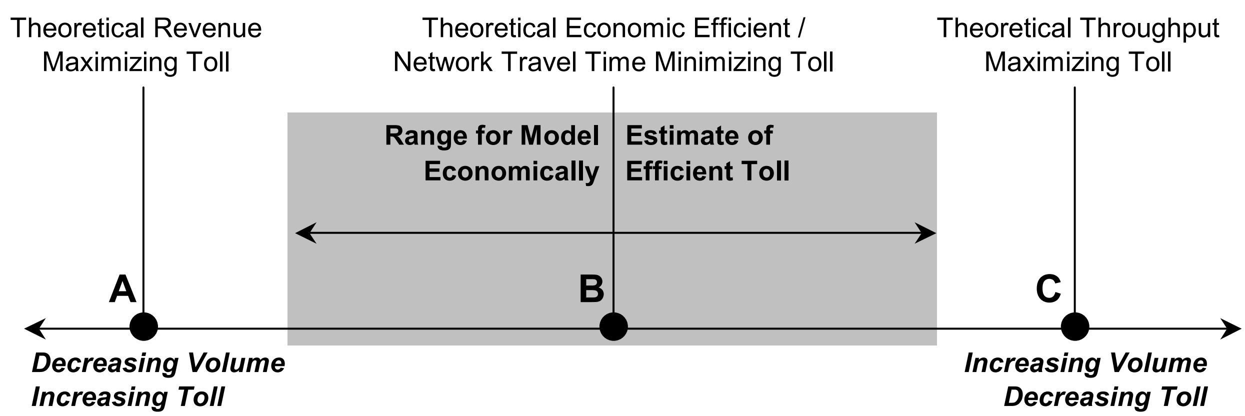
[6] The reader is referred to PSRC's Transportation Pricing Alternatives Study — Technical Memorandum 3: Simulating Congestion Pricing in EMME/2, which details the mathematics of the modification to the model's volume delay function.

Figure 4 Tolling Methodology



In practice, limitations of the model framework and in the assumptions for applying the economically efficient toll structure rarely yield true economic efficiency. Rather, the model estimate for the economically efficient toll rate may fall in a range between the theoretical revenue maximizing toll rate and the throughput maximizing toll rate. To the extent that tolling is more pervasive or ubiquitous, and/or diversion to alternate (un-priced) routes is minimized, the model estimate for the economically efficient toll will converge on the true value, whereas the more isolated tolling is and the more prevalent are diversion opportunities, the more likely the model estimate for the economically efficient toll will diverge from its true value. Figure 5 illustrates the various toll road operating objectives and the range for the model estimates for optimal toll rates.

Figure 5
Toll Rate and Volume Relationships of Theoretical Tolling Objectives



Assessment of the Optimal Toll Time Cost

Since the PSRC regional model's volume-delay function is a function of link volume-to-capacity (V/C) ratios, given an assumption for the desired free-flow speed, the optimal toll for each link and direction — expressed as a time cost per mile — can be derived based solely on the model output V/C ratios. The marginal cost of delay equation is provided below, with Table 6 illustrating the one-to-one correspondence between selected V/C ratios and the optimal toll, as a minutes per mile time cost, for a facility with an assumed free-flow speed of 60 mph. Figure 6 on the following page plots the volume-delay relationships with and without consideration of the external delay costs.

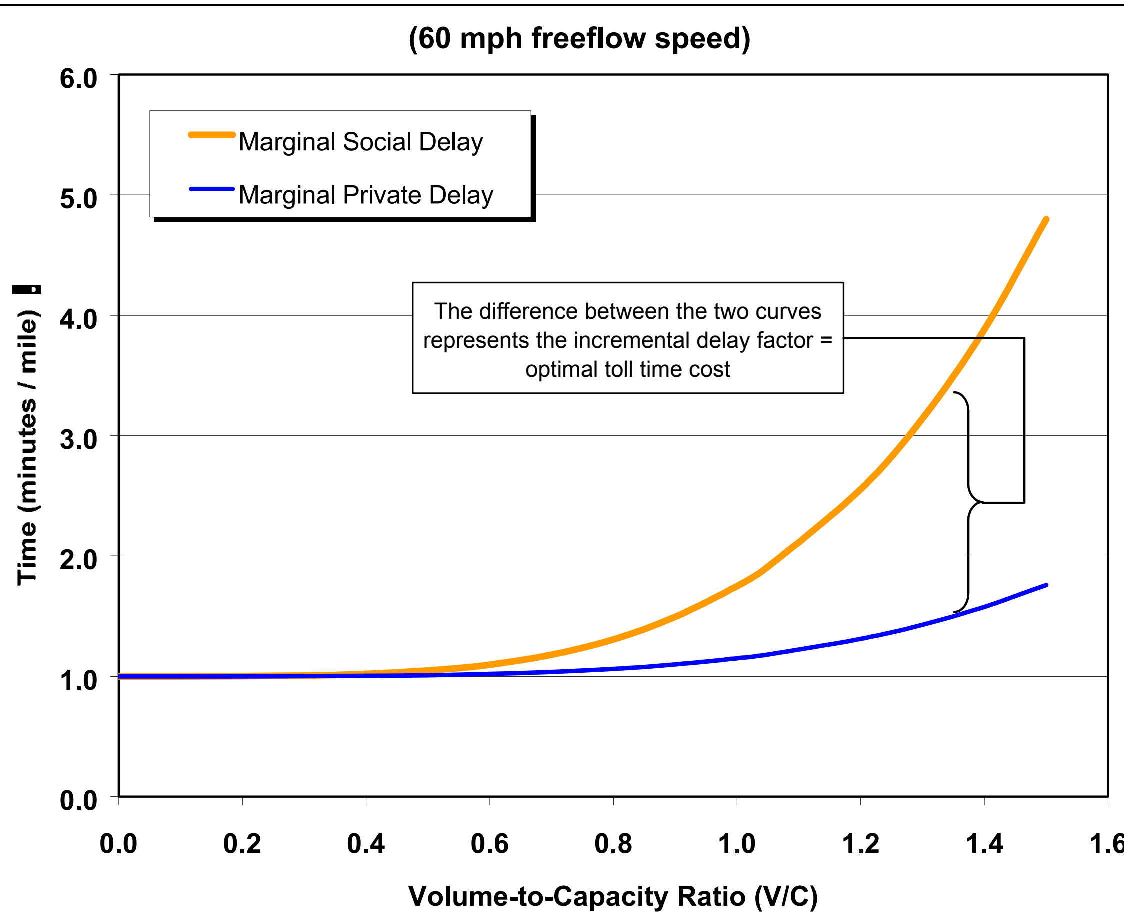
$$m(v) = \underbrace{t_0\left[1 + 0.15\left(\frac{v}{c}\right)^4\right]}_{\text{private "own" delay cost}} + \underbrace{\left[t_0 \cdot 0.6\left(\frac{v}{c}\right)^4\right]}_{\text{external delay cost = toll time cost}}$$

where $m(v)$ = marginal social cost of an additional vehicle
t_0 = free-flow time for a link distance (speed)
v = hourly traffic volume for all lanes
c = hourly capacity, all lanes

Table 6
Optimal Toll Time Costs by V/C Ratio for a 60 mph Facility

V/C Ratio (60 mph free-flow speed facility)	*Incremental Delay Factor = Optimal Toll Time Cost (minutes / mile)*	*V/C Ratio (60 mph free-flow speed facility)*	*Incremental Delay Factor = Optimal Toll Time Cost (minutes / mile)*
0.0	0.000	0.8	0.246
0.1	0.000	0.9	0.394
0.2	0.001	1.0	0.600
0.3	0.005	1.1	0.729
0.4	0.015	1.2	1.244
0.5	0.038	1.3	1.714
0.6	0.078	1.4	2.305
0.7	0.144	1.5	3.038

Figure 6
Volume-Delay Functions for "Own" and "Total" Vehicle Marginal Delay



The difference between the two curves in Figure 6 indicates the optimal toll time cost for the resulting model V/C ratio for the with toll case. For every model link in which tolls are applied, the modified volume-delay function results in a with-toll V/C from which that link's toll rate can be derived. Note that the higher the free-flow (design) speed for the facility, the lower the "optimal" economically efficient toll, all else equal. For example, at a V/C of 0.9, the optimal toll time cost is 0.394 minutes per mile for a 60 mph facility, as shown in Table 6. In contrast, a 50 mph facility yields a toll time cost of 0.472 minutes per mile at a V/C of 0.9. At first glance, this result seems counter-intuitive, based on the logic that a higher speed would generate additional time savings over alternative routes, and thus, a higher toll/greater willingness to pay by users. In a static sense, this is true, though in reality, there are several dynamic factors at work that can make the resulting toll rate go either direction. A 60 mph facility would tend to have a higher capacity than a 50 mph facility. Therefore, at a V/C ratio of 0.9, the 60 mph facility not only moves more vehicles, but also has greater room for additional vehicles, and thus the time cost that one additional vehicle places on all other vehicles — the optimal toll time cost — is smaller.

The future network applied for regional tolling of the seven facilities modeled with pricing assumes that all of these facilities would have a free-flow or design speed of 60 mph.

Estimating Values of Time

Since tolls within the modeling framework are expressed as time costs per mile, it is necessary to convert these to monetary amounts using value of time information. In this context, value of time is defined as a roadway user's willingness to pay to avoid delay, measured in dollars per hour. Value of time has been shown to be closely related to household income levels or average wage rates; in fact, there is evidence that, for commute trips, the ratio of in-vehicle travel time to the wage rate is generally constant across a wide range of income levels. The challenge lies in estimating an appropriate value of time for setting toll rates, because a person's willingness to pay to avoid delay varies by income, trip purpose, peak versus off-peak times of day, travel mode, level of traveling comfort, and even with the level of congestion, which increases travel time uncertainty.

The literature on the value of travel time is extensive and well developed; Small (1999) provides an excellent review of current research. Values of time in research studies are most often determined by conducting stated preference survey (SPS) techniques in which travelers are asked about their willingness to pay for various trade-offs regarding expected travel time and variability. Mode choice models are estimated using the SPS results and the marginal rates of substitution between the costs and travel times of alternatives choices are evaluated. Alternatively, attitudinal panel studies can be used to assess values of time and willingness to pay for delay reduction and/or travel time reliability. A panel study uses repeated surveys of the same sample of users over time to track household income, trip making and travel behavior, route choice, etc., and infers values of time based upon repetitive revealed behavior. This method is particularly useful for assessing values of time for route choices that involve an existing toll facility, and has been employed as part of a series of studies for the I-15 Congestion Pricing Project in San Diego.

In considering the application of tolls on major highway facilities within King and south Snohomish Counties, the necessary market research of users and resulting studies have simply not been done for this or any comparable groups of users. Given this study's objective to assist decision-makers in examining region-wide tolling impacts with an eye toward evaluating if further research, modeling and analysis is warranted, it is necessary to draw upon the experience of studies in other areas to estimate values of time for area travelers. This is typically done by relating the value of time to average wage rates in other areas and then applying the resulting proportion to local wage rates.[7] The experience of other toll facilities, especially those that are dynamically priced adjacent to a parallel un-priced roadway (e.g., SR-91 in Orange County, California) can also provide useful information on willingness to pay.

Several studies have been undertaken to measure value of time. Supernak (2001) summarizes a review of these studies, noting the following.

> Cambridge Systematics (1977) estimated that commuters in the Los Angeles area valued in-vehicle time for non-business travel at 72 percent of their wage. MVA Consultancy (1987) estimated that the value of time of commuters in England varied between 22 and 55 percent of gross wage for high-income earners, and over 100 percent for the lowest income earners. Hensher (1989) estimates a value of time for Australian commuters at 28 percent of their gross wage. Small (1992) summarizes these and other studies, with the conclusion that a "reasonable average value of time for journey to work is 50 percent of the gross wage rate."

One of the challenges in estimating and measuring value of time is understanding what exactly it represents a willingness to pay for, as factors other than delay reduction that may be "hidden" in the value of travel time if not controlled for separately. For example, if other travel characteristics such as comfort/convenience or travel time reliability are not controlled for, then their values may be reflected in the "observed" value of time, making the measure less than ideal for comparing modes and route choices. Congestion often increases the willingness to pay for travel time reductions — here the congestion is increasing willingness to pay to reduce uncertainty, in addition to reducing delay. This suggests that the selection of a appropriate fraction of the prevailing wage rate to serve as the value of time, when based on toll experience elsewhere, should take into account all the attributes users were paying for, which may be more than just delay reduction.

Some interesting results have come to light based upon studies of SR-91. The Cal Poly Applied Research and Development Facilities and Activities (ARDFA) transportation research group conducted a three year series of studies on the impacts of the SR-91 Variable Toll Express Lane facility that opened on December 27, 1995. Objectives included evaluating the impacts of variable-toll express lanes along SR-91 in California while also gaining insight into traveler's reactions to market-based road pricing as a solution to increasing congestion along California's highways. Relevant findings included:

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[7] In 2000, the average wage rate in King County was $23.66 as estimated from Washington State Employment Security Department data on covered employment and total wages and salaries paid.

- There exists a strong correlation between tolled express lane patronage and travel time savings. In spring 1997, the percentage of SR-91 travelers who used the express lanes ranged from about 7% in the mid-day off-peak, when time savings were minimal, to a high of 35% during the peak hour when delay to freeway users was an estimated 12-13 minutes. These observations imply a value of time for SR-91 commuters of $13-14 per hour. However, implied values of time across points in time vary substantially.
- Despite the correlation between travel time savings and the percentage of SR 91 traffic using the toll lanes, some toll lane users choose to use the toll lanes under traffic conditions where the expected value of their time savings is clearly less than the tolls paid. Driving comfort and the perception of greater safety were cited by travelers as the principal supplemental benefits motivating this behavior.
- Surveys conducted with SR-91 peak period travelers provide evidence that many commuters overestimated their true time savings when using the express lanes. This implies that actual values of time may be less than studies have estimated, or that users are "valuing" other travel attributes such as reliability in their travel time savings estimates.

Market research and mode choice model estimation for SR-15 in San Diego suggest a mean value of time of about $16 per hour, although it is noted that the population using this corridor is relatively affluent. In this case, the models did not separately control for travel time reliability, such that the value of "time savings" also includes the value of those unmeasured reliability improvements that generally go along with them for toll facilities.

Finally, there is considerable evidence that the distribution of time values varies considerably from the average value, both across users as well as across trip purposes and times of day. On the margin, values of time, and thus willingness to pay tolls, can significantly exceed their average values. Examples include wage-earners who can ill-afford to be late for work; travelers on the way to the airport, and commuters on their way daycare facilities, who will incur substantial monetary penalties if they are late picking up their children.

Values of Time Assumed in the Optimal Toll Rates

Current literature generally converges on a value of time for work trips equal to 50% of average wage rates for the relevant travel market area (Small, 1999 & 1992, and Waters, 1992). It is recognized that this value primarily represents a willingness to pay for delay reduction, but may also include a willingness to pay for reducing uncertainty, improving comfort, and other attributes generally associated with toll facilities and value pricing. In King County, the most recent available employment data from the Washington State Employment Security Department yields an average wage rate of $23.66 per hour for the year 2000. One-half of this amount, or $11.83, was thus established as the "base value of time" and used to generate toll rates per mile from the optimal toll time costs.

An additional "low value of time" was also established at one-third the average wage rate, or $7.89 per hour for two reasons. First, it is recognized that other previous studies in the Puget Sound region, notably the I-405 EIS effort, have assumed values of time closer to one-third the average King County wage rate. Second, a "half wage rate" value of time may include willingness-to-pay factors for other travel attributes beyond reducing delay, which may or may not vary between tolled and un-priced routes.

Since the true value of time for regional travelers is yet unknown, the use of two values yields a range that likely includes the relevant average value. Two time values also yields two sets of optimal toll rates, which helps to bracket the resulting revenue forecasts within a range that is more likely to include the true revenue possible. However, in this context, two sets of optimal toll rates do not allow us to test the toll elasticity of demand nor do they impact the expected traffic volumes. Rather, they merely allow us room for error in estimating users' willingness to pay for delay reduction.

Finally, considering that the proposed projects and full implementation of tolling will not take place for several years, the value(s) of time underlying the set of optimal toll rates will need to be inflated to year-of-opening dollars to yield the correct revenue estimates.

Limitations of the Toll Modeling Approach

A key question raised by policy-makers when considering the implementation of a toll facility is how traffic and revenue will be impacted by changes in toll rates. At heart of this question is the concept of toll elasticity of demand — how travel behavior changes with varying toll rates, holding all other variables constant. Demand is said to be inelastic if a *given percentage increase* in the toll rate results in a *smaller percentage decrease* in traffic volumes. When demand is inelastic, marginal increases in the toll rate will generate additional total revenue. Conversely, when demand is elastic, the resulting percentage drop in demand is larger than the percentage increase in the toll, and overall revenue drops. Normally, the demand for any good or service is inelastic at relatively low prices, but becomes increasingly elastic as prices rise. At some price in between, revenue is maximized.

Furthermore, demand becomes more elastic over time as people seek alternatives or reevaluate their travel behavior based upon their own costs and incentives. Thus the toll structure that may maximize revenue in the short-run may become sub-optimal in the long run

Although the methodology developed for the PSRC is intended to identify the optimal or economically efficient toll structure which seeks to minimize overall network travel times, it does not tell us how close or far this is from the revenue maximizing toll, and it cannot tell us by *how much* demand, and thus, revenue will change at different toll rates.

Detailed market research and the specification of a toll mode choice model — both of which would be required to estimate elasticities of demand — are not currently part of the PSRC methodology for simulating congestion pricing within the modeling framework. In the event that the revenue results of this feasibility study are sufficient to warrant the further research and expense, the Next Steps section of this report discusses the steps required to take the traffic and revenue forecasts to the next level.

Land use forecasts used in the regional model, both in terms of quantity and location, are largely a policy exercise based on historical trends and desired growth patterns. In this particular effort, the accuracy of the location of growth is more of a concern than the quantity.

With a 2030 forecast year and a largely urbanized area, the actual quantity of growth is of lesser importance as the area converges on full build out. Assumptions of the location of growth can impact the toll modeling by causing some facilities to experience higher or lower demand levels than others, and in consequence, different toll rates and revenue levels. To some extent this effect is tempered in this study due to the assumption of system-wide toll network, which has a balancing effect. This suggests that a finely-cut intra-facility level of analysis will be less accurate than a broader-level view of the network.

The regional model used for this analysis does not interactively link land use and transportation system characteristics. For instance, future land use patterns are assumed to be fixed, with no land use response to variations in the toll rates or the roadway network. However, the net effects of this consideration may be moderated due to the system-wide tolling approach.

While some base year model inputs are changed to arrive at the future projections, other base year validation parameters such as trip rates and mode choice coefficients are assumed to be fixed over time. The implementation of a regional toll network presents a noteworthy change to the system that the model may not fully capture. The application of an impedance to each link as a surrogate for an actual monetary cost of a toll may have some application limitations in accounting for changes in behavior.

TRAFFIC AND TOLL REVENUE FORECASTS

Given that the purpose of this study is to enlighten the ongoing discussion of tolling rather than provide "investment-grade" revenue forecasts, the approach here is to establish a range that likely encases the toll revenue potential of regional pricing and is informative to further policy decisions. The determination of the revenue range involves varying three key parameters: (1) optimal toll rates were varied by applying the two different values of time, (2) the base toll multiplier applied to trucks was varied, and (3) additional variation was generated by estimating revenue with and without tolling on weekends.

Regional Toll Modeling Assumptions and Application

The highway network of the PSRC Regional Travel Demand Model was prepared for modeling the future build-out scenario indicated in Table 5 for both the base year (1998) and the forecast year (2030). This required taking the future 2030 highway network — which includes all committed and funded regional projects in the PSRC, WSDOT and local Transportation Improvement Plans — and further codifying the proposed improvements resulting from the SR-509 extension, SR-99 Alaskan Way Viaduct replacement, SR-520 Trans-Lake and I-405 widening mega-projects. All of the toll network facilities in this future network were assumed to have a free-flow speed (speed limit) of 60 mph.[8]

Though not part of the SR-509 extension project nor the underlying 2030 network, HOV lanes were coded on the existing portion of SR-509 to give the entire facility two general purpose and one HOV lane per direction. Similarly, SR-99 was coded as a limited access facility of three lanes in each direction between the end of SR-509 at the First Avenue South Bridge and Spokane Street to match with the proposed Alaskan Way Viaduct improvements, even though the former is not part of the latter project. These network assumptions effectively create a contiguous "west corridor" alternative to I-5, thus attracting more traffic from I-5 to SR-509/SR-99 than would otherwise be the case.

Figure 1 in the Executive Summary depicts the regional toll network as modeled. The network was further assumed to include portions of I-5, I-90 and SR-167 in combination with the four mega-project facilities above. This assumption is practical for two reasons. First, by eliminating the high capacity, un-priced alternative facilities, the overall distribution of traffic remains relatively evenly balanced across available highway capacity. Second, it generates significantly more revenue, which is in keeping with the objective to identify the upper bound of revenue potential from a broader regional perspective, recognizing that individual facilities interact as components of a system.

The overall modeling objective was to model the 2030 highway network, for both the base year (1998) and the future year (2030) demand conditions, in order to have two reference points from which to interpolate intermediate year values. Considering model runs with and without tolls, this gives four model scenarios. In addition to the highway network, the future transit network

[8] Note that a lower free-flow speed assumption results in higher optimal toll rates, and thus, more optimistic revenue projections.

was fixed at the 2030 level for modeling both reference years. This was considered to be a conservative assumption, since the 2030 future level of transit service applied to an earlier year will tend to overstate transit usage, and thus understate auto usage, which would result in lower highway demand and toll revenue. Note that the 2030 transit network is defined to include existing service changes since 1998, transit operators' six year plan service improvements through 2007, and a one percent per year increase in transit service thereafter through 2030. In addition, the 2030 transit network assumes the Sound Transit LRT line from Seatac to Northgate as well as services in Phase 1 of the Sound Move Plan.

Although the highway and transit networks were fixed at their 2030 levels, all other model inputs were allowed to vary between the two reference years. For example, the base year model runs utilized the current origin-destination trip matrix representing present demand levels, as well as the existing land use patterns, population and employment, auto operating costs, parking costs, and other system attributes. All of these inputs take on different projected values for the 2030 model runs.

For the "without toll" scenarios, the regional model was run with the standard volume-delay function in order to generate the traffic volumes and corresponding volume-to-capacity (V/C) ratios necessary for identifying the incremental time costs that correspond to the economically efficient "optimal" toll rates.

In addition, the "with toll" scenarios were modeled with the modified volume-delay function which adds an additional impedance corresponding to the external time delay component to simulate the case with the optimal toll in place. The resulting volumes are used to project toll revenue, and can be compared to the without toll volumes to estimate the gross diversion to alternate routes caused by the implementation of tolling.

Revenue Calculation Assumptions

Tolling Mechanism

The following presents some general assumptions regarding the processing of the model outputs and resulting traffic forecasts; the revenue calculations and related facility operating attributes; and the factors that contribute to a range for projected toll revenue under the future build conditions. These assumptions are made for purposes of modeling regional tolls and identifying their upper revenue range potential, and are not intended to reflect any official decisions regarding new highway capacity investments.

The traffic and toll revenue forecasts in this study reflect the assumption of 100% electronic toll collection (ETC). In addition, based upon the methods used to model tolls, it was most appropriate to assume that tolls would be charged on a per-mile basis. In other words, users would be charged only for the distance they travel rather than assuming a set of flat toll rates that simply buy access to specific roadway segments. With ETC, this latter assumption poses no technological challenges that could not be overcome.

Although the ETC and per-mile tolling assumptions are convenient for this modeling exercise, given the nature of regional travel and the myriad of access points within the toll network, it would be practically impossible to consider any other tolling schemes. Manual toll collection and/or flat rate tolls would have tremendous real estate requirements and could be very labor-intensive, not to mention the queuing delays at various toll plazas. A non-trivial amount of toll evasion would have to be tolerated with so many access points, and flat toll rates could require charging cash customers the full amount associated with the maximum potential travel distance to the next toll plaza, regardless of how far they actually travel. While it is not an objective of this study to solve the technological challenges of region-wide toll collection, it is safe to say that manual toll collection is not likely feasible.

It is recognized that the majority of vehicle-trips, if not users, on the regional toll network would be made by local residents who would likely obtain the necessary ETC vehicle transponders. All the same, there will be some infrequent users, visitors, and even regular users who, for whatever reason, will not have transponders and who would thus be excluded from ETC. It is anticipated that license plate recognition technology would be used to bill the registered owner for applicable toll charges plus any administrative fees.[9] It would also be possible to equip rental car fleets with the necessary transponders and have toll charges added to the user's rental fee. Nonetheless, a 100% ETC system will likely deter some travel and/or cause inadvertent or intentional toll evasion. To account for these potential non-revenue trips made by such users — without considering alternative payment methods or enforcement mechanisms/costs — the toll revenue forecasts were conservatively reduced by 5%. It is assumed that this revenue adjustment would compensate for the revenue loss associated with 100% ETC.

In addition, no assumptions have been made regarding the operations and maintenance costs of electronic toll collection, administrative costs of toll collection including billing of vehicles without transponders, or violation enforcement. The revenue ranges reported reflect gross toll revenues before consideration of any such costs. Estimation of operating, maintenance and administrative costs for region-wide tolling are beyond the scope of this study.

Toll Periods, Toll Rates and Implementation Timing

Year 2014 is the assumed year of opening for the four mega-project investments. To the extent that this date is optimistic, it will understate the annual toll revenue potential. The 1998 base year and 2030 forecast horizon have been used to interpolate 2014 volumes, and thus, V/C ratios and optimal toll rates for this opening year and other intermediate years through 2030.

In addition, cursory consideration was given to the toll revenue that might be possible during a seven year implementation period from 2006 – 2013, as the proposed improvements are being implemented. Since detailed information regarding project phasing and construction impacts was not available, and if it was, would have necessitated extensive additional modeling efforts, a simplified partial revenue approach was adopted. In effect, toll revenues from 2006 – 2013 were estimated for the entire toll network using the off-peak toll rates, which are sub-optimal for the peak periods.

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[9] The 407 Express Toll Route in Toronto, Canada is 100% ETC but allows for autos without transponders to be charged tolls via automatic license plate recognition. A bill is sent to the registered vehicle owner for the toll amount (on a per kilometer basis), along with an administrative charge of approximately $1.75 US.

For revenue estimation purposes, four weekday toll time periods were modeled to span a 15 hour toll period from 6 AM to 9 PM. They include an AM peak period, a PM peak period, a midday period and a two hour evening. The regional model provides AM and PM peak period as well as off peak results in terms of volumes and V/C ratios. These are then used to calculate directional toll rates for these periods, where the off-peak model tolls are applied both the midday and evening periods on weekdays, and all day on weekends.

Traffic volume and flow data from WSDOT was used to determine location and facility specific characteristics for identifying intervals to apply the model-derived toll rates. Specifically, actual traffic volume data was used for two purposes: (1) to develop 24-hour traffic profiles for representative sites on each facility by direction in order to assess current and future location-specific peak and off-peak periods and truck percentage profiles, and (2) to determine weekday to weekend daily adjustment factors for both autos and trucks.

Traffic data was collected at various points that were considered representative of the facility or its sections. Early November traffic data was used as a review system-wide traffic volumes in the Puget Sound Region indicated that November data most closely resembled annual average traffic conditions. Traffic counts for three days, Tuesday, Wednesday and Thursday, were averaged to obtain a weekday averages. Traffic counts for Saturday and Sunday were averaged to determine a weekend average.

The roughly 400 individual model links and their associated toll rates within the regional model were aggregated to 46 analysis segments to make the calculations manageable. The analysis segments were chosen to combine contiguous or homogenous links with similar capacities and traffic characteristics, where inter-link toll rate variation was insignificant. Locations and lengths for the 46 analysis segments are provided in the Appendix information. Combining the 46 analysis segments with three time periods and two directions yields a total of 276 different toll rates that are applied to generate the base annual revenue projections. This number is then doubled by applying the alternate value of time used to help set the projected revenue range.

The 46 analysis segments were further aggregated to 13 sections across the seven facilities for purposes of identifying the location-specific peak period intervals. Table 7 presents the time intervals over which the AM peak, PM peak and off peak period tolls would be in effect for these 13 sections. The above mentioned weekend day factors for total traffic and trucks, as a percentage of the respective weekday factors, is also given. These intervals and percentages were then appropriately applied to all 46 analysis segments.

Table 8 presents the truck percentages that were applied to these 13 sections by daily time periods. The weekend truck percentages were reduced using the factors indicated in Table 7. The truck percentages are a key input to the revenue calculations as the toll modeling outputs apply to all non-HOV vehicles including trucks. Since trucks pay a different toll rate than autos, it is necessary to segregate them out from the regular passenger vehicles.

Table 7
Toll Categories, Time Periods and Weekend Traffic Factors by Facility

Route & Segment (North to South)	*Peak Tolls / Peak Direction*	*Peak Tolls / Reverse Direction*	*Off-Peak Tolls / Both Directions*	*Weekend % of Week-day 15 Hr Toll Period*	
				Total Vehicles	*Trucks Only*
SR-99: Roy St. to 1st Ave S.	NB 6 - 9 AM SB 3 - 7 PM	SB 6 - 9 AM NB 3 - 7 PM	9 AM - 3 PM & 7 - 9 PM	67.8%	13.0%
SR-509: 1st Ave S to I-5	NB 6 - 9 AM SB 3 - 7 PM	SB 6 - 9 AM NB 3 - 7 PM	9 AM - 3 PM & 7 - 9 PM	67.8%	37.2%
I-5: I-405 to Northgate	SB 6 - 9 AM NB 3 - 7 PM	NB 6 - 9 AM SB 3 - 7 PM	9 AM - 3 PM & 7 - 9 PM	88.9%	35.0%
I-5: Northgate to I-90	SB 6 AM - 11 AM NB 2 PM - 7 PM	NB 6 AM - 11 AM SB 2 PM - 7 PM	11 AM - 2 PM 7 - 9 PM	80.7%	45.4%
I-5: I-90 to Southcenter	NB 6 - 9 AM SB 3 - 7 PM	SB 6 - 9 AM NB 3 - 7 PM	9 AM - 3 PM & 7 - 9 PM	75.6%	32.7%
I-5: Southcenter to Pierce Co.	NB 6 - 9 AM SB 3 - 7 PM	SB 6 - 9 AM NB 3 - 7 PM	9 AM - 3 PM & 7 - 9 PM	82.9%	26.2%
SR-520: I-5 to NE 40th St	EB 6 AM - 11 AM WB 2 PM - 7 PM	WB 6 AM - 11 AM EB 2 PM - 7 PM	11 AM - 2 PM 7 - 9 PM	65.1%	35.0%
SR-520: NE 40th St to End	WB 6 - 10 AM EB 3 - 7 PM	EB 6 - 10 AM WB 3 - 7 PM	10 AM - 3 PM & 7 - 9 PM	67.8%	37.2%
I-90: I-5 to I-405	EB 6 AM - 11 AM WB 2 PM - 7 PM	WB 6 AM - 11 AM EB 2 PM - 7 PM	11 AM - 2 PM 7 - 9 PM	59.9%	41.1%
I-90: I-405 to SR-900	WB 6 - 10 AM EB 2 - 7 PM	EB 6 - 10 AM WB 2 - 7 PM	10 AM - 2 PM & 7 - 9 PM	65.1%	39.1%
I-405: I-5 to SR-520	SB 6 - 9 AM NB 3 - 7 PM	NB 6 - 9 AM SB 3 - 7 PM	9 AM - 3 PM & 7 - 9 PM	79.9%	35.9%
I-405: SR-520 to Southcenter	SB 6 AM - 11 AM NB 2 PM - 7 PM	NB 6 AM - 11 AM SB 2 PM - 7 PM	11 AM - 2 PM 7 - 9 PM	78.0%	37.4%
SR-167: I-405 to Pierce Co.	NB 6 - 10 AM SB 2 - 7 PM	SB 6 - 10 AM NB 2 - 7 PM	10 AM - 2 PM & 7 - 9 PM	80.0%	27.4%

Table 8
Toll Time Periods and Truck Percentages

Route & Segment (North to South)	AM Peak Intervals: 6 - 9 AM	AM Peak Intervals: 6 - 10 AM	AM Peak Intervals: 6 - 11 AM	Midday Intervals: 9 AM - 2 PM	Midday Intervals: 9 AM - 3 PM	Midday Intervals: 10 AM - 2 PM	Midday Intervals: 10 AM - 3 PM	Midday Intervals: 11 AM - 2 PM	PM Peak Intervals: 2 PM - 7 PM	PM Peak Intervals: 3 PM - 7 PM	Evening: 7 - 9 PM	Off-Peak (Midday+ Evening)
SR-99: Roy St. to 1st Ave S.	3.2%				5.4%					2.7%	1.8%	4.8%
SR-509: 1st Ave S to I-5	3.2%				5.4%					2.7%	1.8%	4.8%
I-5: I-405 to Northgate	5.7%				9.2%					4.5%	5.4%	10.5%
I-5: Northgate to I-90			10.4%					12.6%	7.7%		6.9%	15.9%
I-5: I-90 to Southcenter	6.5%				9.1%					4.4%	4.9%	10.1%
I-5: Southcenter to Pierce Co.	7.7%				9.9%					5.6%	5.2%	10.9%
SR-520: I-5 to NE 40th St			5.7%					7.4%	4.7%		2.9%	8.8%
SR-520: NE 40th St to End		5.2%					7.3%			4.2%	2.8%	8.1%
I-90: I-5 to I-405			3.5%					5.3%	3.0%		2.4%	6.4%
I-90: I-405 to SR-900		6.8%				13.6%			6.9%		7.3%	15.8%
I-405: I-5 to SR-520	5.1%				6.5%					3.2%	3.1%	7.2%
I-405: SR-520 to Southcenter			7.5%					9.3%	5.2%		4.2%	11.1%
SR-167: I-405 to Pierce Co.		9.2%				12.2%			5.4%		4.4%	13.6%

As previously described, the values of time used to compute the spectrum of toll rates in cents per mile ranges from one-third (low) to one-half (base) of the annual wage rate for King County. In year 2000 dollars, the average wage rate was $23.66, resulting in a low value of time of $7.89 and a base value of time of $11.83. These amounts are escalated to year of collection dollars using the State of Washington's forecast for the Implicit Price Deflator for personal consumption. The resulting spectrum of toll rates, expressed as minimums, maximums, and weighted averages by facility and time period, in inflated (year of collection) dollars is given in Table 9 for the base value of time. The same toll rate spectrum for the low value of time is presented in Table 10. Additional toll rate tables for 2014 expressed in constant 2000 dollars as well as for 2030 in constant 2000 and inflated dollars are provided in the Appendix for both values of time.

Table 9
Spectrum of Optimal Toll Rates for 2014 in Inflated Dollars
(Base Value of Time)

Toll Facility	Toll Distance	PM Peak Period — $ / mi			AM Peak Period — $ / mi			Off-Peak / Weekend — $ / mi		
		Minimum	Maximum	Average	Minimum	Maximum	Average	Minimum	Maximum	Average
SR-99	6.1	$0.04	$0.22	$0.11	$0.04	$0.22	$0.11	$0.04	$0.04	$0.04
SR-509	11.8	$0.04	$0.14	$0.09	$0.04	$0.14	$0.09	$0.04	$0.04	$0.04
I-5	43.1	$0.04	$0.33	$0.14	$0.04	$0.21	$0.10	$0.04	$0.05	$0.04
I-405	30.2	$0.04	$0.19	$0.11	$0.04	$0.11	$0.07	$0.04	$0.04	$0.04
SR-167	14.1	$0.04	$0.20	$0.12	$0.04	$0.15	$0.09	$0.04	$0.04	$0.04
I-90	13.3	$0.04	$0.25	$0.13	$0.04	$0.18	$0.08	$0.04	$0.04	$0.04
SR-520	12.8	$0.06	$0.42	$0.19	$0.04	$0.28	$0.12	$0.04	$0.07	$0.05
Network	**131.3**	**$0.04**	**$0.42**	**$0.13**	**$0.04**	**$0.28**	**$0.09**	**$0.04**	**$0.07**	**$0.04**

Note: All amounts in year of collection dollars

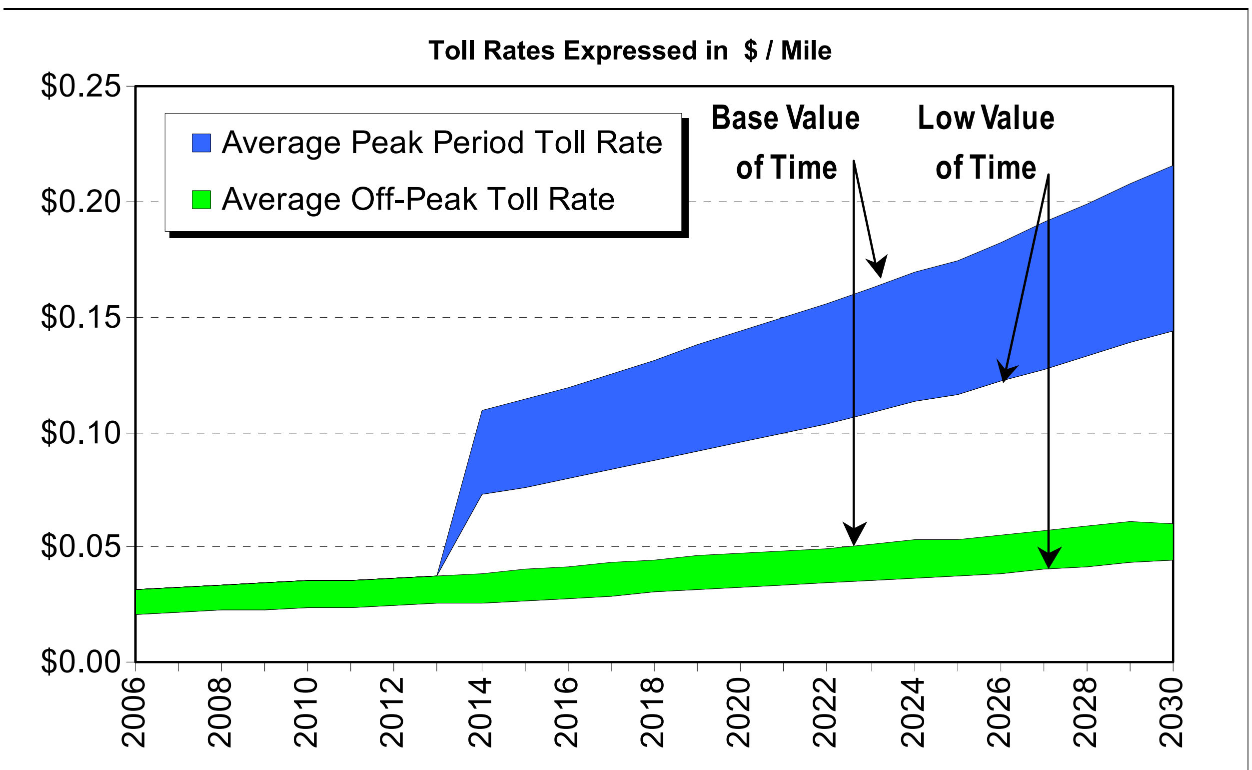
Table 10
Spectrum of Optimal Toll Rates for 2014 in Inflated Dollars
(Low Value of Time)

Toll Facility	Toll Distance	PM Peak Period — $ / mi			AM Peak Period — $ / mi			Off-Peak / Weekend — $ / mi		
		Minimum	Maximum	Average	Minimum	Maximum	Average	Minimum	Maximum	Average
SR-99	6.1	$0.03	$0.15	$0.07	$0.03	$0.15	$0.07	$0.03	$0.03	$0.03
SR-509	11.8	$0.03	$0.09	$0.06	$0.03	$0.09	$0.06	$0.03	$0.03	$0.03
I-5	43.1	$0.03	$0.22	$0.09	$0.03	$0.14	$0.06	$0.03	$0.03	$0.03
I-405	30.2	$0.03	$0.12	$0.08	$0.03	$0.07	$0.05	$0.03	$0.03	$0.03
SR-167	14.1	$0.03	$0.13	$0.08	$0.03	$0.10	$0.06	$0.03	$0.03	$0.03
I-90	13.3	$0.03	$0.17	$0.09	$0.03	$0.12	$0.05	$0.03	$0.03	$0.03
SR-520	12.8	$0.04	$0.28	$0.13	$0.03	$0.19	$0.08	$0.03	$0.05	$0.03
Network	**131.3**	**$0.03**	**$0.28**	**$0.09**	**$0.03**	**$0.19**	**$0.06**	**$0.03**	**$0.05**	**$0.03**

Note: All amounts in year of collection dollars

Figure 7 graphically depicts the system-wide, weighted average peak and off-peak toll rates in inflated dollars over time. In this case, the AM and PM toll rates of Table 9 and Table 10 have been combined, and the bandwidth represents the range of average tolls created by the two values of time considered. Off peak rates are shown beginning in 2006 (they would apply to all periods through 2013), and peak period differentiation is introduced in 2014.

Figure 7
Average Peak Period and Off-Peak Toll Rate Ranges Over Time



In accordance with industry practice, truck toll rates were assumed to be a multiplier of the auto toll, typically ranging from 2× to 4× based upon the number of axles (2, 3, and 4+). Since truck types and sizes vary widely, it was assumed that the average truck corresponded to an auto toll multiplier of 3×. For calculation purposes, the 3× factor was used to generate the high end of the estimated revenue range, and a more conservative 2× factor was used for the low end.

Note that the optimal toll rates would increase over time for two reasons:

1. Growth in traffic demand will necessitate an increasingly higher optimal toll in order to elicit the appropriate travel behavior and diversion to maintain an economically efficient traffic flow; and

2. Over time, general inflation will increase the average wage rate, and thus the value of time, the latter of which drives the calculation of the optimal toll rate.

The results herein assume that the posted toll rates per mile are maintained at their optimal toll levels through annual increases for both inflation and rising demand. Clearly, the operating objectives of the toll facility and the need to manage against congestion will need to be well explained, as imposing annual toll increases may be met with public resistance, let alone the fact that on some occasions, an increase in excess of inflation would be necessary.

The downside risk is that failure to increase the optimal toll rates for either of these two effects could lead to the occurrence or recurrence of congestion on the regional toll network, which could likely reduce person-throughput, and by inefficiently wasting the time of those caught in congestion, negate part of the reason why tolls are imposed in the first place.

Regional Toll Revenue Projections

The traffic projections from the regional model were converted to weekday and weekend day vehicle miles traveled (VMT) by segment and travel direction for the toll periods identified in Table 7. The respective model estimated optimal toll rates were then applied to these VMT data, with the noted adjustments for truck percentages and ETC non-participation/evasion loss, to develop the revenue estimates.

As discussed in detail elsewhere herein, a range of revenue that might be possible with the assumed regional toll network and the economically efficient toll modeling approach was considered by varying the value of time underlying the optimal toll rate as well as varying the truck toll multiplier and the inclusion of weekend toll revenues.

The resulting annual toll revenue forecast ranges for the assumed regional toll network in both constant and inflated dollars are presented in Table 11 through 2030. Table 12 presents each facility's contribution to the high end of the projected total revenue range for selected years in inflated, year of collection dollars. Table 13 presents the same for the low end revenue projection, also in inflated, year of collection dollars. In either case, the operating objective is minimization of overall network travel times. Revenue maximizing toll rates would yield additional revenue, but also higher social travel time costs.

Table 11
Regional Toll Network Annual Revenue Ranges (Constant & Inflated $)

Year	Constant Year 2000 Dollars		Inflated (Year of Collection) Dollars	
	LOW END	HIGH END	LOW END	HIGH END
	Low Time Value 2x Truck Toll Factor No Weekend Tolls	Base Time Value 3x Truck Toll Factor Weekend Tolls	Low Time Value 2x Truck Toll Factor No Weekend Tolls	Base Time Value 3x Truck Toll Factor Weekend Tolls
2006	$ 56.0 M	$ 81.3 M	$ 62.9 M	$ 91.3 M
2007	$ 57.6 M	$ 83.7 M	$ 66.2 M	$ 96.1 M
2008	$ 59.3 M	$ 86.2 M	$ 69.7 M	$ 101.2 M
2009	$ 61.1 M	$ 88.7 M	$ 73.3 M	$ 106.5 M
2010	$ 62.9 M	$ 91.3 M	$ 77.2 M	$ 112.1 M
2011	$ 64.7 M	$ 94.0 M	$ 81.4 M	$ 118.3 M
2012	$ 66.6 M	$ 96.7 M	$ 86.1 M	$ 125.1 M
2013	$ 68.5 M	$ 99.6 M	$ 91.2 M	$ 132.4 M
2014	$ 184.3 M	$ 334.3 M	$ 252.1 M	$ 457.3 M
2015	$ 187.7 M	$ 340.0 M	$ 264.1 M	$ 478.5 M
2016	$ 191.1 M	$ 345.8 M	$ 276.8 M	$ 500.9 M
2017	$ 194.6 M	$ 351.7 M	$ 290.5 M	$ 525.1 M
2018	$ 198.2 M	$ 357.7 M	$ 305.7 M	$ 551.8 M
2019	$ 201.8 M	$ 363.9 M	$ 322.3 M	$ 581.0 M
2020	$ 205.5 M	$ 370.1 M	$ 340.6 M	$ 613.4 M
2021	$ 209.5 M	$ 376.9 M	$ 355.7 M	$ 640.0 M
2022	$ 213.6 M	$ 383.9 M	$ 371.6 M	$ 667.8 M
2023	$ 217.7 M	$ 390.9 M	$ 388.3 M	$ 697.2 M
2024	$ 222.0 M	$ 398.2 M	$ 406.0 M	$ 728.2 M
2025	$ 226.3 M	$ 405.5 M	$ 424.4 M	$ 760.5 M
2026	$ 230.9 M	$ 413.4 M	$ 444.2 M	$ 795.4 M
2027	$ 235.6 M	$ 421.5 M	$ 465.3 M	$ 832.3 M
2028	$ 240.4 M	$ 429.7 M	$ 487.4 M	$ 871.2 M
2029	$ 245.3 M	$ 438.1 M	$ 510.7 M	$ 912.0 M
2030	$ 250.3 M	$ 446.7 M	$ 535.1 M	$ 954.9 M

Table 12
Annual Revenue by Facility for Selected Years — <u>High End</u> Estimates

Toll Facility	Toll Distance	Year of Collection Dollars in Millions					
		2006	2013	2014	2020	2025	2030
SR-99	6.1	$3.1 M	$4.1 M	$14.8 M	$18.9 M	$22.6 M	$27.4 M
SR-509	11.8	$2.7 M	$3.7 M	$20.1 M	$25.8 M	$30.7 M	$37.0 M
I-5	43.1	$41.7 M	$60.2 M	$189.2 M	$251.8 M	$310.5 M	$387.0 M
I-405	30.2	$22.5 M	$33.6 M	$119.0 M	$162.9 M	$205.3 M	$261.6 M
SR-167	14.1	$6.3 M	$8.9 M	$32.5 M	$42.6 M	$51.7 M	$63.2 M
I-90	13.3	$6.4 M	$9.6 M	$41.8 M	$57.0 M	$71.7 M	$92.4 M
SR-520	12.8	$8.6 M	$12.3 M	$40.0 M	$54.4 M	$68.0 M	$86.4 M
Network	**131.3**	**$91.3 M**	**$132.4 M**	**$457.3 M**	**$613.4 M**	**$760.5 M**	**$954.9 M**

Table 13
Annual Revenue by Facility for Selected Years — Low End Estimates

Toll Facility	Toll Distance	Year of Collection Dollars in Millions 2006	2013	2014	2020	2025	2030
SR-99	6.1	$2.3 M	$3.0 M	$8.5 M	$10.9 M	$13.0 M	$15.8 M
SR-509	11.8	$2.0 M	$2.7 M	$11.5 M	$14.8 M	$17.7 M	$21.4 M
I-5	43.1	$28.1 M	$40.6 M	$102.8 M	$137.7 M	$170.5 M	$213.1 M
I-405	30.2	$15.4 M	$23.0 M	$64.4 M	$89.2 M	$113.4 M	$145.6 M
SR-167	14.1	$4.3 M	$6.0 M	$17.9 M	$23.7 M	$28.9 M	$35.5 M
I-90	13.3	$4.7 M	$7.0 M	$24.1 M	$33.0 M	$41.7 M	$53.8 M
SR-520	12.8	$6.2 M	$8.8 M	$23.0 M	$31.4 M	$39.2 M	$49.9 M
Network	**131.3**	**$62.9 M**	**$91.2 M**	**$252.1 M**	**$340.6 M**	**$424.4 M**	**$535.1 M**

Figure 8 shows the contribution share of each toll facility to the overall system-wide revenue projections for 2014 under the high end projection, though the low end distribution differences are negligible. Figure 9 graphically presents the range for total network toll revenue (presented in Table 11) in inflated or year of collection dollars. Additional revenue information by facility expressed in constant 2000 dollars can be found in the Appendix.

Figure 8
2014 Distribution of Regional Toll Revenue by Facility

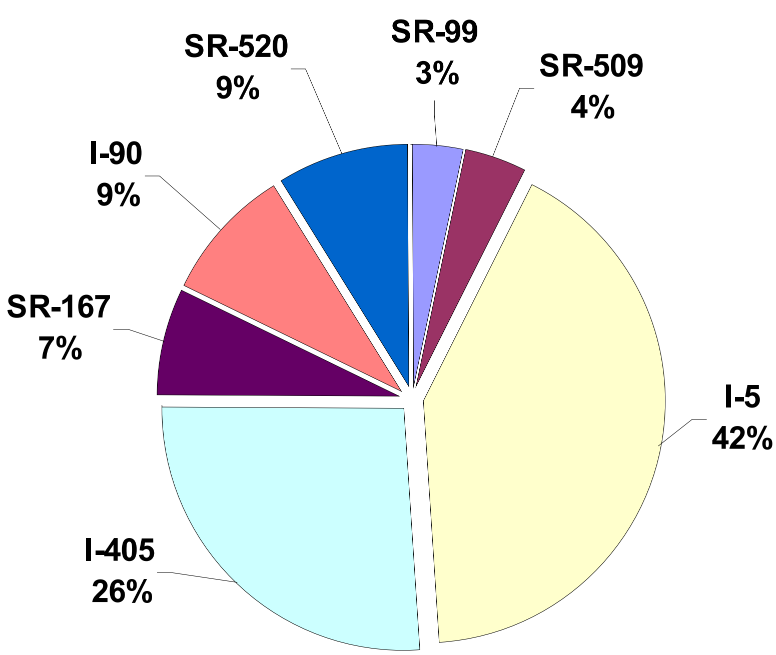
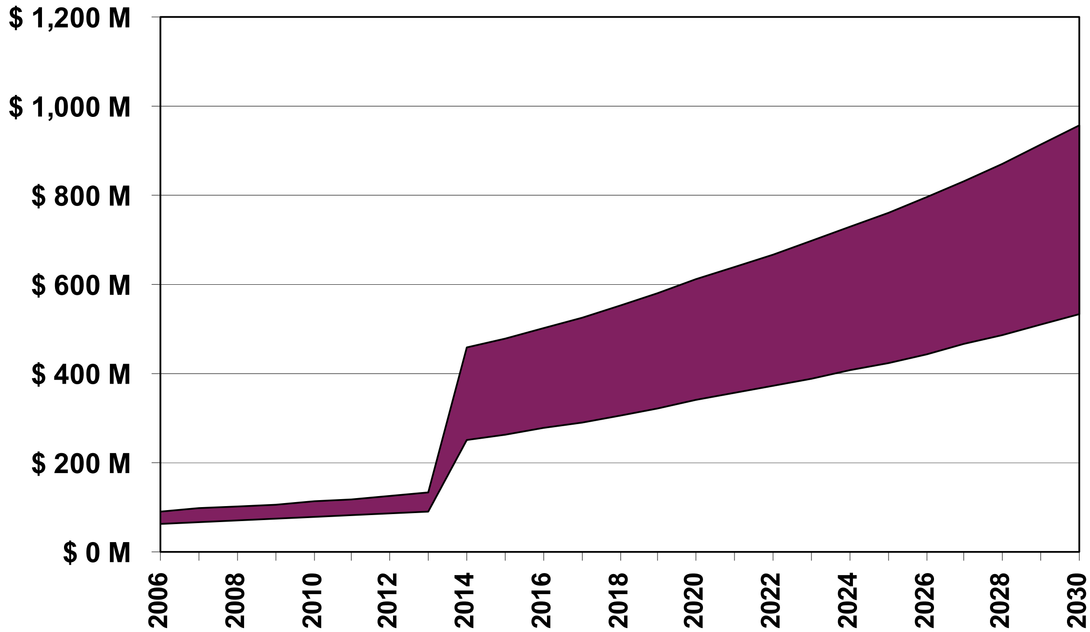


Figure 9
Regional Toll Network Projected Revenue Range in Inflated Dollars



For the "implementation period" from 2006 through 2013, during which the entire regional toll network is assumed to be tolled at the off-peak toll rates, annual revenue is estimated to range from between $63 and 91 million in 2006, growing to between $91 and 132 million by 2013. These numbers need to be carefully considered for two reasons. First, the assumption of sub-optimal tolling of the entire regional network as early as 2006 is a convenient way to roughly gauge revenue collections during a period of toll implementation, but does not realistically convey the likely phased implementation of improvements and concurrent toll collection systems. Second, if optimal tolls were uniformly applied to the regional network during this period, the reality could be that the reduced capacity of pre-improvement facilities undergoing construction would actually lead to higher real toll rates and lower highway traffic volumes than would be observed once the improvement projects were completed. Nonetheless, public resistance may make it impossible to implement the full optimal toll rates prior to completing the various network improvements.

It is interesting to note that the 2013 partial revenue method yields a result that approaches the I-5 contribution to the regional total revenue range (listed in Table 12 and Table 13 for 2014). However, if I-5 were tolled singularly, it is likely that it would generate less revenue than as part of a regional system, although additional modeling work would be required to verify a range for how much. Nonetheless, the simplified revenue estimate for 2006 – 2013 may be a rough proxy for implementing tolls singularly on I-5 from the outset of construction in 2006 through 2013. This might be a reasonable first option, especially for managing congestion on I-5, since although construction will directed elsewhere, construction impacts on I-405, SR-99 and SR-509 would definitely cause diversion to I-5 if it were not tolled to manage congestion. Growth in the projected revenue reflects both higher demand levels over time, which puts upward pressure on the optimal toll rates, and a rising value of time that follows wage inflation.

Typical Toll Costs for Representative Trips

Table 14 presents the typical user toll costs for a range of representative highway trips, as assessed from the base value of time average toll rates as shown in Table 9. Toll costs are shown for the PM peak, AM peak and off-peak time periods. In some cases for trips over 10 miles, multiple routings are presented with their respective costs.

Table 14
2014 Toll Costs for Representative Highway Trips

Representative Trips	*Route*	*Toll Distance by Facility (miles)*	*Total Toll Distance (miles)*	*PM Peak Period Trip Toll Cost**	*AM Peak Period Trip Toll Cost**	*Off-Peak Period Trip Toll Cost**
Less Than 5 Miles						
West Seattle to South Lake Union	I-5 between W. Seattle Bridge & Mercer St.	3.7	3.7	$0.50	$0.36	$0.15
	SR-99 (AWV) between W. Seattle Bridge & Roy St.	4.4	4.4	$0.49	$0.48	$0.17
5 to 9.99 Miles						
Northgate to Downtown Seattle	I-5 between Northgate & Olive Way	6.7	6.7	$0.91	$0.65	$0.26
Downtown Bellevue to UW	I-405 between NE 8th & SR-520 SR-520 between I-405 & Montlake	1.0 5.8	6.8	$1.22	$0.76	$0.30
Issaquah to Downtown Bellevue	I-90 between SR-900 & I-405 I-405 between I-90 & NE 8th Street	5.8 2.7	8.6	$1.06	$0.64	$0.33
Burien to Downtown Seattle	SR-509 between SR-518 & 1st Ave. S. Bridge SR-99 (AWV) btw. 1st Ave. S. Bridge & Midtown	5.5 4.1	9.6	$0.94	$0.93	$0.37
Bothell (SR-522 I/C) to Downtown Bellevue	I-405 between SR-522 & NE 8th Street	9.9	9.9	$1.12	$0.68	$0.38
10 to 14.99 Miles						
Issaquah to Kirkland	I-90 between SR-900 & I-405 I-405 between I-90 & SR-520 SR-520 between I-90 & Lake Wash. Blvd	5.8 3.7 0.7	10.3	$1.31	$0.80	$0.40
	I-90 between SR-900 & I-405 I-405 between I-90 & NE 85th Street	5.8 6.8	12.7	$1.53	$0.93	$0.49
Snohomish Co. Line to Downtown Seattle	I-5 between 244th St. SW & Olive Way	11.6	11.6	$1.57	$1.12	$0.45
Issaquah to Downtown Seattle	I-90 between SR-900 & I-5 I-5 between I-90 & James Street	13.3 0.7	14.0	$1.81	$1.11	$0.55
Downtown Seattle to Redmond	I-5 between Olive Way & SR-520 SR-520 between I-5 & SR-202	1.9 12.8	14.7	$2.70	$1.71	$0.66
15 to 19.99 Miles						
Lynnwood to Downtown Seattle	I-5 between SR-524 & Olive Way	15.3	15.3	$2.08	$1.48	$0.60
Renton to UW	I-405 between SR-169 & SR-520 SR-520 between I-405 & Montlake	10.5 5.8	16.3	$2.29	$1.41	$0.67
Lynnwood to Downtown Bellevue	I-5 between SR-524 & I-405 I-405 between I-5 & NE 8th Street	1.1 16.5	17.6	$2.02	$1.24	$0.68
Kent to Kirkland	SR-167 between 228th St. & I-405 I-405 between SR-167 & SR-520 SR-520 between I-405 & Lake Wa. Blvd.	4.9 12.5 0.7	18.1	$2.15	$1.37	$0.71
20 to 24.99 Miles						
Lynnwood to Downtown Bellevue	I-5 between 44th Ave. W & SR-520 SR-520 between I-5 & I-405 I-405 between SR-520 & NE 8th Street	12.3 7.0 1.0	20.4	$3.13	$2.10	$0.84
Kent to Kirkland	SR-167 between 228th Street & I-405 I-405 between SR-167 & NE 85th Street	4.9 15.6	20.5	$2.37	$1.50	$0.80
Federal Way to Downtown Seattle	I-5 between 320th Street & SR-516 (SR-509 Ext) SR-509 between SR-516 & 1st Ave. S. Bridge SR-99 (AWV) between 1st Ave. S. Bridge & Midtown	5.3 11.8 4.1	21.1	$2.21	$1.99	$0.82
	I-5 between 320th St. I/C & James Street	21.5	21.5	$2.91	$2.08	$0.84
Auburn to Downtown Bellevue	SR-167 between SR-18 & I-405 I-405 between SR-167 & NE 8th Street	12.0 11.5	23.5	$2.76	$1.83	$0.91
Greater than 25 Miles						
Renton to Lynnwood	I-405 between SR-169 & I-5 I-5 between I-405 & SR-524	25.9 1.1	27.0	$3.10	$1.89	$1.05
	I-405 between SR-167 & I-5 I-5 between I-405 & SR-524	2.3 27.0	29.3	$3.92	$2.77	$1.15
Everett to Tacoma	I-5 between I-405 & Pierce Co. Line	43.1	43.1	$5.84	$4.17	$1.69
	I-405 between Swamp Creek & Tukwila Interchanges I-5 between I-405 & Pierce County Line	30.2 15.0	45.2	$5.46	$3.52	$1.76

* Reflect vehicle miles traveled (VMT) weighted average toll rates and overall toll costs

Diversion of Trips from Tolled Facilities

Compared with the toll-free case, introduction of optimal tolls on the assumed network of limited access highways in King and South Snohomish Counties will result in the diversion of some vehicle trips away from these facilities during the toll period. These diverted trips fall into several categories:

- Travelers who make the same trip but divert to an alternate, un-priced route, usually another highway or arterial street;
- Travelers who continue to make the same trip on the tolled facility using their private vehicle, but traveling at a different time of day, when there would be a lower toll rate;
- Travelers who continue to make the same trip at the same time of day, but who will now travel in a vehicle that can use toll-free HOV lanes , either in a high occupancy vehicle with three or more occupants or in a bus;
- Travelers who will choose to change their trip behavior, either traveling to a different destination, such as one in a different direction that they can get to without using a tolled highway, or one nearer to their origin so that the shorter distance results in a lower toll charge to get there; and
- Travelers who opt to eliminate trips, either by not traveling at all, or by combining the functions of two or more trips into a single trip.

The average toll period model diversion rates by facility due to optimal pricing are shown in Table 15. As the road improvements and associated tolling is not assumed to be fully implemented prior to 2014, results for 1998 – 2013 reflect simulations of these years' demand levels with the future (2014) toll network and associated improvements. Actual diversions rates vary somewhat by location, time of day and direction of travel for each facility.

Table 15
Average Toll Period Diversion Rates by Facility and Analysis Year

Toll Facility	*Toll Distance*	*Rates of Diversion* 1998	2006	2013	2014	2020	2025	2030
SR-99	6.1	-10.8%	-11.3%	-11.7%	-11.8%	-12.1%	-12.4%	-12.7%
SR-509	11.8	-17.3%	-17.4%	-17.4%	-17.4%	-17.4%	-17.4%	-17.5%
I-5	43.1	-16.2%	-17.1%	-17.8%	-17.9%	-18.6%	-19.1%	-19.7%
I-405	30.2	-13.0%	-14.6%	-15.9%	-16.1%	-17.2%	-18.1%	-19.0%
SR-167	14.1	-17.1%	-17.6%	-18.0%	-18.0%	-18.4%	-18.6%	-18.9%
I-90	13.3	-6.4%	-6.4%	-6.4%	-6.4%	-6.4%	-6.4%	-6.4%
SR-520	12.8	-16.2%	-16.8%	-17.3%	-17.4%	-17.8%	-18.2%	-18.5%
Network	**131.3**	**-14.4%**	**-15.3%**	**-16.0%**	**-16.1%**	**-16.8%**	**-17.3%**	**-17.9%**

Note that the diversion percentages shown in Table 15 apply only to non-HOV travel; the actual change in highway traffic volumes would be somewhat less due to a portion of the diverted vehicles converting to 3+ HOVs where they would use the toll-free HOV lanes.

The relatively low diversion rates for I-90 reflect the excess capacity and superior travel conditions of this facility relative to the SR-520 alternative as well as the lack of alternatives for Mercer Island residents. Essentially, I-90 is the preferred choice for cross-lake travel for trips that could reasonably use either I-90 or SR-520. However, modeling results from the Trans-Lake Washington project indicate that the diversion rates for I-90 would double to approximately 13% if additional general purpose capacity were added to SR-520 under the eight lane scenario (six general purpose lanes). Additional capacity on SR-520 tends to balance out the relative travel advantages that I-90 otherwise provides. Moreover, approximately one-quarter of the I-90 bridge traffic between I-5 and I-405 is either to or from Mercer Island. Because travel to or from the island has no other alternative but to use I-90, the diversion rate for these trips is very low.

The regional travel demand model used in this analysis does an adequate job of estimating the overall levels of diversion, but it is less able to provide reasonable estimates of what would become of the diverted vehicles, particularly for diversion to arterial streets. The model is most able to estimate diversions to other routes and other modes, and is least able to estimate diversions to other time periods or eliminations of trips.[10] As a result, the model may overestimate the impact of tolling on adjacent parallel highways and arterial streets, particularly if some of the diverted trips are actually eliminated or shifted to less congested times. Moreover, as the arterial network gets congested, the model's volume-delay function may not sufficiently discourage arterial street use (as an alternative to the tolled highway), which could cause the model to over-estimate toll diversion, and in so doing, underestimate optimal toll rates — both of which would underestimate the revenue yield.

The model processes for determining diversion, interpretation of the resulting diversion rates, and the impacts on the arterial system warrant further research and analysis. Though the model attempts to minimize overall network travel times, it is unclear by how much the arterial street network is affected, as well as what share of diverted trip end up on the arterials. Examining the 2030 traffic forecast with and without tolls indicates that, at least on a daily basis, total vehicle miles traveled on the arterial system would not increase with the presence of tolls on the limited access facilities, and may actually decrease slightly. However, intra-zonal trips are not usually assigned in network modeling, and these trips increase by about 2% when tolls are simulated. Whether or not these short intra-zonal trips actually occur and represent an significant increase in VMT, or are just a model proxy for trips that would otherwise be eliminated except for model's fixed demand constraint is unclear. Nonetheless, there are bound to be individual arterial segments that would undoubtedly be loaded with increased traffic at certain times of day.

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[10] The overall network demand remains relatively fixed in the regional model, which may not be a reasonable assumption with implementation of regional tolling.

Toll Revenue Assumptions and Their Likely Effects on Outcomes

Limitations of the regional model when stretched to simulate highway pricing have been discussed. Given the nature of these forecasting methods and the lack of in-depth market research regarding user behavior with tolls, a concerted effort was made to generally use conservative revenue calculation assumptions where possible to avoid producing forecast scenarios that might be considered too optimistic. Below are a list of assumptions and model outcomes categorized as either optimistic/uncertain or conservative. While it is not possible to quantitatively measure the net effects of these, the fact that the conservative assumptions/outcomes considerably outnumber the optimistic/uncertain ones suggests that the resulting toll revenue range presented herein are not overly optimistic.

Optimistic and Uncertain Assumptions/Outcomes

- Though not part of any planned project, an SR-99 limited access extension between the First Avenue South Bridge and Spokane Street was modeled which effectively connects SR-99 with SR-509 to form a better western corridor option to I-5.
- Updates to the future land use assumptions and associated population and employment projections that are inputs to the regional model were not revised. It is conceivable that widespread tolling may eventually impact future residential and business location choices, and even land use patterns, reorganizing the proximity of households to their jobs. It is unclear as to what degree such change might occur, and moreover, redistribution of land use patterns within King County is less likely due to the balancing effects of tolling most all of the major highway facilities.
- It has been assumed that the revenue loss due to electronic toll collection non-participation or evasion would be 5% system-wide. Unfortunately, there is no comparable situation and associated empirical data for testing this hypothesis. Existing ETC facilities either have a cash payment option, an adjacent parallel roadway, or do not represent conversion to tolls of an existing facility. Moreover, the widespread implementation assumed in this case would tend to make ETC participation almost non-avoidable. It should also be reiterated that no operating nor transactions costs have been included in the revenue estimates.
- The assumption that toll rates will rise with inflation and growing demand in a timely manner to maintain their optimal levels may not necessarily occur because of administrative, legal or other operational constraints not anticipated in this report.

Conservative Assumptions/Outcomes

- The revenue projections assume that tolls are not collected from 9 PM to 6 AM. While most of this time period has relatively low volumes of traffic, there are times when conditions may warrant tolling certain night hours, which could generate some additional revenue.
- At times on weekends, traffic congestion can approach and even surpass weekday levels, and the optimal toll rates would move in the same direction. However, rather than attempting to identify and model these periods, it was conservatively assumed that on average, weekend conditions would mirror those of the weekday off-peak periods. Moreover, the low end of the revenue range excludes weekend tolls altogether.

- The regional model uses the Bureau of Public Road's volume-delay function with an exponential coefficient that may overstate the diversion impacts, particularly to the arterial street network. The same BPR volume-delay function specification is used for both freeways and arterials, despite the fact that they operate differently as demand increases. While these inputs are being reviewed and updated as part of the PSRC model update process, in the interim, potentially overstated diversion may result in understated toll rates and toll revenue.[11]
- The values of time used to convert the model-derived toll time costs to dollars per mile range from conservative at one-third the average wage rate to reasonable at one-half the average wage rate. However, user's willingness to pay can increase significantly above these values on the margin, especially during congested peak periods. However, no attempt was made to model these potential peak period effects.
- A case can be made that real wage rates, and thus the imputed real values of time, show positive growth. Put another way, productivity increases are projected to cause nominal wage rates, and thus values of time, to grow faster than projected general inflation rates. This would then lead to increasingly higher tolls over time than those used herein. However, real wage rates/values of time were assumed to be constant, with nominal values matching projected inflation.
- The model output V/C ratios, from which the optimal toll rates are computed, were capped at 1.25, which results in a maximum toll rate per mile of 29¢ in year 2000 dollars. In a few cases, the model results indicated higher V/C ratios, which would have yielded exponentially higher toll rates on certain segments, and thus more optimistic revenue foreasts.
- The regional model was applied with the 2030 transit and HOV networks for both the base year (1998) and future year (2030) model runs. For years prior to 2030, this overstates the true transit levels of service available, and thus may have the effect of overstating transit use, and thus, understating roadway demand, toll rates, and resulting revenue.
- The economic efficiency toll modeling approach yields toll rates that seek to maximize total net social benefits of using the network, particularly that of minimizing overall network travel time. These toll rates are less than those that would maximize revenue, though the latter cannot be readily estimated with existing tools. Nonetheless, to the extent that demand becomes more elastic over time, the difference between the model-derived economically efficient tolls and those that would maximize revenue may decrease.

Annual Toll Revenue Purchasing Power

A revenue projection raises the question of how much will the annual cash flow buy, in terms of capital investment, via bond debt financing. Several factors would influence this, including the duration of construction; prevailing interest rates; debt structure, duration and issuance costs; projected rate of revenue growth; and required debt service coverage, among others. Moreover,

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[11] The 2000 Highway Capacity Manual recommends coefficients for the BPR volume-delay function by facility type that generally exceed the value of 4 used in the regional model. This results in travel time delay costs that rise faster with increasing volume, especially on arterial streets, which would tend to make arterials less attractive alternatives with tolls on the highways.

the range of investments being considered, their interactive effects on toll revenue, and their combined duration of construction further complicates matters. It is unreasonable to assume that toll revenues could be used to finance a large portion of initial construction costs, as toll revenue bonds typically require commencement of debt service funded from toll revenues (as opposed to capitalized as part of the project cost for which borrowing is employed) no more than a couple of years after issuance.

Essentially, a realistic assessment of the financial capacity of the toll revenue estimates herein would require detailed information regarding the timing of other revenue sources, proposed debt instruments, construction costs and phasing, toll collection implementation and technologies, and a host of other factors (e.g., debt service coverage requirements, issuance costs, debt terms and duration, etc.), which would then serve as input to a detailed financial analysis of regional highway investments.

In the absence of such a financial analysis, all that can be considered is the somewhat unrealistic case where toll revenues would be immediately available to begin debt service payments. Under this scenario with prevailing interest rates and other reasonable assumptions, each $1 million of annual toll revenue, net of any operating costs, could leverage approximately $9-11 million of capital investment via the sale of 25 year municipal revenue bonds or similar debt instruments. To the extent that bond proceeds are brought forward, delaying the commencement of toll revenues for repayment, the net proceeds will decrease.

RELATED STUDIES AND TOLL FACILITY INFORMATION

Comparison with the County Executives Revenue Forecasts

Recognizing that implementing the needed regional transportation improvements will require new local revenue sources, the County Executives of King, Snohomish, and Pierce Counties proposed a Regional Transportation Improvement District (RTID) mechanism for generating local revenue to pay at least of portion of the costs for a list of regional projects. This plan was presented to their respective county councils on May 1, 2002, and is expected to evolve into a ballot measure to take forward to the voters as early as November 2002. For each project, specific revenue sources and yields for the 10-year period from FY 2003-2012 were estimated. Put simply, the package indicated how much funding (for which projects) the regional mechanism would provide under various levy rate assumptions. Five types of revenue were included as funding sources in the county executives' package:

- Sales tax;
- Vehicle licensing fees;
- Local option motor vehicle excise tax;
- Unused transit tax capacity (King County only); and
- Tolls

It is notable that there is basic parity between each county's revenue projections and the sum of the project costs on that county's list. It appears that the county-specific forecasts for all of these revenue sources, except for tolls, were developed in conjunction with WSDOT, which relied on information from the Departments of Licensing and Revenue, and were calculated according to well-established projection methodologies.

The forecasts for toll revenues contained in the County Executives' package, however, are qualitatively different from the forecasts for the other revenue sources. The time frame and resources available for developing toll forecasts were insufficient to employ a rigorous forecasting methodology including an examination of the effects of tolling on driver behavior. As such, the toll revenue forecasts contained in the County Executives' package are very preliminary. Nonetheless, it is helpful to understand how they were developed in order to explain notable differences between the toll revenue figures in the County Executives' package and the regional toll revenue forecasts allocated by facility presented herein.

In the County Executives' package, tolls are only used to help fund three mega-projects in King County: the Alaskan Way Viaduct replacement, Translake Washington (SR-520) improvements, and I 405 widening and improvements. Table 16 presents the County Executives' expected contributions from tolls for fiscal years 2003-2012 by each of the three mega-projects.

Table 16
County Executives' Proposed Plan 10-Year Toll Revenue Projections
FY 2003-2012

Project	Toll Revenue (10 Years)	Regional Contribution Assumed	Total	% of Regional Funding from Tolls
Alaskan Way Viaduct	$500 M	$1.5 B	$2 B	25%
405 Tukwila to Woodinville	$450 M	$1.0 B	$1.45 B	31%
SR 520 Translake	$600 M	$800 M	$1.4 B	43%

For I-405 and SR-520, the method used to come up with toll revenues for the 2003-2012 period was relatively simple.[12] Traffic volumes from WSDOT's *2000 Annual Traffic Report* were compiled for a selected "midpoint" location on each facility. Estimated traffic growth rates were then applied for each year through 2012. Toll revenue was then simply estimated as a flat $1.00 toll for the projected annual traffic volume crossing at these identified locations. In essence, toll revenues were estimated by multiplying the projected traffic at a single point for all times of day and days of the week by $1.00. The totals for each year were then summed up to arrive at ten-year estimates of toll yields by facility. The Alaskan Way Viaduct toll revenue projection of $500 million appears to be more speculative. This figure is well in excess of 10 years of annual traffic all paying a $1.00 toll, which would likely equate to something closer to $300 million.

While this methodology has the advantage of being easy to compute and understand, it has significant shortcomings. Among its disadvantages — relative to the regional toll modeling approach of this study — are that tolls are assumed to be collected on all trips, regardless of time of day or day of the week This assumption may not be realistic from a public acceptance standpoint, and it is undesirable from the perspective of trying to manage demand by pricing according to prevailing conditions. In some cases, charging the same toll at all times may tend to overstate the revenue potential, depending on the toll rate assumed, because it ignores the fact that diversion would occur and vary by time of day and trip purpose.

At the same time, this approach could also underestimate the revenue potential. The true revenue potential of tolling cannot be discerned by forecasting on the basis of single cordon lines—particularly on long corridors like I-405. Such a method would tend to miss a significant number of facility users that do not cross that point. For instance, this approach would not capture I-405 trips that begin and end without crossing the Bellevue cordon line, as would a trip from Kirkland to Woodinville.

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[12] This method was not specified in the transmission of the County Executives' package to the councils. Rather, it appears that it was used by staff to produce order of magnitude toll revenue estimates.

In addition, the County Executives approach does not account for the distance traveled; a person traveling the length of I-405, for instance, would pay no more than a person using this highway to from downtown Bellevue to Kirkland. Similarly, it does not distinguish between passenger vehicles and trucks. Because trucks tend to reap greater benefits from time savings while also causing more damage to the roadway, it may be desirable to charge these vehicles higher tolls.

Also, this approach does not account for the toll elasticity of demand, that is changes in travel behavior — diversion to alternate routes, trip consolidation, mode changes, and/or trip elimination — due to changes in the cost (price) of travel, nor the potential effects of inflation.

Context of Other Toll Modeling Efforts

Concurrent with this study of the feasibility and revenue potential of regional tolling, individual project planning and engineering work for several of the facilities in the proposed regional toll network is also being conducted by WSDOT and various consultants. Specifically, the SR-520 Translake, I-405, and Alaskan Way Viaduct corridor are in various stages of the Environmental Impact Statement (EIS) process, in which tolling options are being considered.

For the Alaskan Way Viaduct, a Draft Toll Feasibility Study has been conducted and the Final is expected shortly. The preliminary results of this work indicate that while tolling is feasible, the demand characteristics of this relatively short roadway as a stand-alone facility, combined with the availability of un-priced alternative routes, limit the revenue potential to an amount much less than that anticipated by the County Executives' plan. When leveraged with bonding, the Viaduct's toll revenues are likely to cover well less than 10% of the project cost.

Toll revenue projections for an independent SR-520 Translake Washington project have not yet been completed. However, preliminary modeling results suggest that the volumes and congestion levels for the six-lane alternative are expected to be similar to those projected for the SR-520 component of this study's regional toll modeling effort, and thus, so too would this similarity extend to toll revenue. This would suggest that the revenue potential of SR-520 may be more independent of the existence of region-wide tolling than that of the other facilities that do not serve such a captive market.

Modeling has also been done for the I-405 widening project EIS, though the toll modeling work is preliminary, and has to-date focused primarily on high occupancy toll (HOT) and managed lanes concepts — whereby single occupant vehicles (SOVs) are allowed to purchase excess managed lane capacity — as opposed to the tolling of all lanes of the facility. Formal revenue estimates for the modeling work to-date have not been produced.

Demand Effects of Removing Tolls on Washington State Toll Bridges

To put into perspective the roughly 15% toll diversion to other routes expected for the Alaskan Way Viaduct or its replacement facility, traffic data was analyzed before and after removal of tolls on the two most recent such facilities in Washington State.

SR-520 Floating Bridge Experience

The Governor Albert Rosellini Evergreen Point Floating Bridge (SR-520) opened in August 1963 with a $0.35 toll each way. The toll rate was set to pay debt service costs for construction bonds. In today's dollars, the $0.35 toll in each direction is equivalent to $1.70. With projected inflation, this corresponds to $2.30 in 2014, the assumed year of implementation for regional tolling as modeled herein.

The SR-520 bridge toll — still at $0.35 per direction — was removed in June 1979. At the time of removal, the real cost of the toll had declined considerably since the bridge opening to about $0.85 in today's dollars, or $1.14 in year 2014 dollars.

In 1978, the last full year of toll operations, AADT numbered 60,452 vehicles, versus 56,752 on the un-priced parallel I-90 Floating Bridge. By 1980, AADT on SR-520 had jumped 19.3% to 72,139 while traffic on I-90 fell by 7.9% to 52,283 for no other apparent reason than SR-520 becoming more attractive. These results suggest that toll diversion on SR-520 was approximately 16.2%, with over one-third of the toll-inhibited vehicle trips diverted to I-90, and the remainder either north around the lake or not at all.

Hood Canal Bridge Experience

The $2.00 toll on the Hood Canal Bridge was removed on August 29, 1985. In 1984, annual average daily traffic (AADT) was 5,982 vehicles with the toll. In 1986, AADT jumped 38% to 8,253 vehicles in the first full year without the toll. This seems to indicate that in the year before the toll was eliminated, it was causing a diversion of 27.5% of would-be vehicle trips to either be made using alternative routes, or more likely in this case, to not be made at all.

Toll Rate and Revenue Information for Selected North American Toll Facilities

The following tables provide some comparable information for 13 selected toll roads or systems of toll roads in the U.S. and Canada. While the list of facilities is by no means comprehensive, it does provide some context for the implementation of tolls in the Puget Sound Region. Table 17 identifies some of the general characteristics of these facilities, including length, year of opening, type and configuration, payment methods, etc. Table 18 presents pricing, revenue and utilization information for the same 13 facilities. Some of the toll road characteristics have been simplified for presentation purposes, with the intent of providing summary-level comparisons. Toll rates, where presented as ranges, may arise from variable pricing by time of day / demand levels / ETC discounts, may be due to fixed toll rates charged over segments with different lengths, or some combination of these factors. Revenue for different facilities can vary greatly based on a number of factors including the operating objective, length and configuration of the facility, toll rate, and the travel market/demand levels served.

Table 17
General Characteristics of Selected North American Toll Facilities

Toll Facility & Location	Year Opened	Principal Operating Objective	Overall Length (miles)	Type / Configuration	Access	Open to Trucks?	Payment Methods (ETC = electronic toll collection)	Toll Parameters / Unit
SR-91 Orange Co., CA	1995	Revenue maximization	10	Located in the median of the SR-91 freeway	End-points only	No	100% ETC	Variable rate for entire facility distance
I-15 FasTrak San Diego, CA	1996	Throughput target	8	Two-lane, reversible facility in the median of I-15.	End-points only	No	100% ETC	Variable rate for entire facility distance
Dulles Greenway Dulles, VA	1995	Revenue maximization	14	Privately toll road. Four lanes with reversible options.	Multiple access / exit points	Yes	ETC, credit card & cash (no coins)	Flat rate between exits and/or plazas
SR-267 Dulles Toll Road Dulles, VA	1984	Revenue target (retirement of debt, O&M costs)	14	8 lane (4 lanes in each direction) limited access highway	Multiple access / exit points	Yes	ETC & cash	Flat rate between exits and/or plazas
Harris County Toll Roads Houston TX	1987	Revenue target (retirement of debt, O&M costs)	83	Limited access tolled ring road	Multiple access / exit points	Yes	ETC & cash	Flat rate between exits and/or plazas
New Jersey Turnpike NJ	1951	Revenue target (retirement of debt, O&M costs)	118	Dual toll facilities; trucks prohibited from using one of the two roads.	Multiple access / exit points	Yes[1]	ETC, cash & tokens	Flat rate between exits and/or plazas
407 Express Toll Route (ETR) Toronto, Canada	1997	Revenue maximization	68	Limited access toll road	Multiple access / exit points	Yes	100% ETC	Per kilometer rate between exits and/or plazas
E470 Denver, CO	1998	Revenue target (retirement of debt, O&M costs)	46	Limited access toll road. Partial ring road	Multiple access / exit points	Yes	ETC & cash	Flat rate between exits and/or plazas
Homestead Extension (HEFT) FL	1974	Revenue target (retirement of debt, O&M costs)	47	Limited access toll road	Multiple access / exit points	Yes	ETC & cash	Flat rate between exits and/or plazas
Polk Parkway FL	1998	Revenue target (retirement of debt, O&M costs)	25	Limited access toll road	Multiple access / exit points	Yes	ETC & cash	Flat rate between exits and/or plazas
Southern Connector, Greenville, SC	2001	Revenue target (retirement of debt, O&M costs)	16	Limited access toll road	Multiple access / exit points	Yes	ETC & cash	Flat rate between exits and/or plazas
SR-73 San Joaquin Toll Road Orange Co., CA	1996	Revenue target (retirement of debt, O&M costs)	15	Limited access toll road	Multiple access / exit points	Yes	ETC & cash	Variable rates between exits and/or plazas
SR-261, SR-241 & SR-133 Foothill & Eastern Toll Roads Orange Co., CA	1993–1999	Revenue target (retirement of debt, O&M costs)	36	Limited access toll road	Multiple access / exit points	Yes	ETC & cash	Flat rates between exits and/or plazas

[1] Trucks are excluded from one of the two roadways in this dual roadway configuration

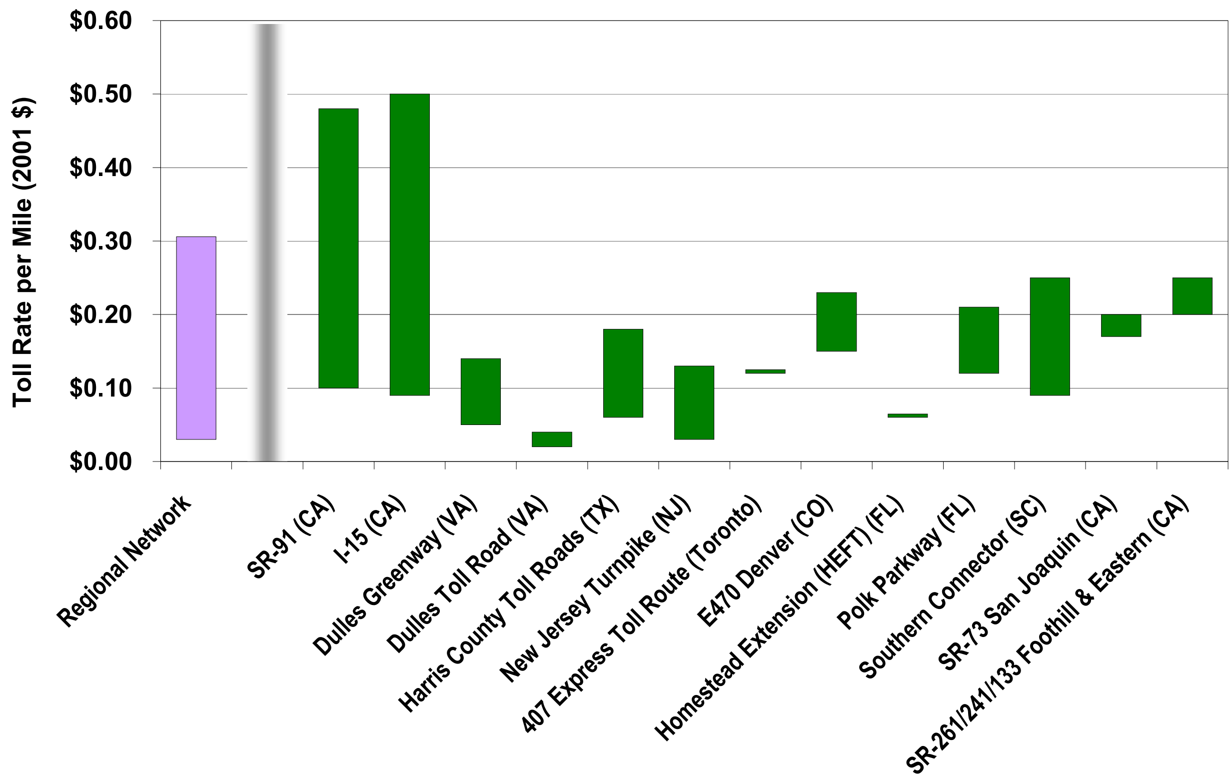
Table 18
Pricing, Revenue & Utilization for Selected North American Toll Facilities

Toll Facility & Location	Toll Rates / Mile	Variable Tolls (by Time of Day or Demand)?	Range of Trip Cost (varies with toll rate & distance)	HOV Discount?	Annual Toll Revenue	Average Revenue / Mile	Annual Vehicle Trips	Annual Toll Transactions	Revenue/ Vehicle Trip	Revenue / Transaction
SR-91 Orange Co., CA	\$0.10 – \$0.48	Yes	\$1.00 – \$4.75	Yes	\$21.3 M (2000)	\$2.1 M	7.7 M	7.7 M	\$2.77	\$2.77
I-15 FasTrak San Diego, CA	\$0.09 – \$0.50	Yes	\$0.75 – \$4.00 (up to \$8.00 w/ incident)	Free	\$1.2 M (2002)	\$0.15 M	4.4 M	N/A	\$0.27	N/A
Dulles Greenway Dulles, VA	\$0.05 – \$0.14	Yes	\$0.50 – \$2.00	No	\$19.8 M (2000)	\$1.4 M	14.4 M	N/A	\$1.38	N/A
SR-267 Dulles Toll Road Dulles, VA	\$0.02 – \$0.04[3]	No	\$0.25 – \$0.50	Free	\$31.2 M (1996)	\$2.2 M	N/A	96.2 M	N/A	\$0.32
Harris County Toll Roads Houston TX	\$0.06 – 0.18[3]	No	\$0.25 – \$1.00 (\$1.50 - 2.00 for Ship Bridge)	No	\$217.8 M (2001)	\$1.7 M	140 M	N/A	\$1.02	N/A
New Jersey Turnpike NJ	\$0.03 – 0.13	Yes[1]	\$0.45 – \$5.5	No	\$392 M (2000)	\$3.3 M	N/A	214.9 M	N/A	\$1.82
407 Express Toll Route (ETR) Toronto, Canada	\$0.12[2]	No	\$0.46 – \$8.25[2]	No	\$244 M (2001)	\$3.6 M	86.1 M	N/A	\$2.83	N/A
E470 Denver, CO	\$0.15 – \$0.23[3]	No	\$0.50 – \$5.75	No	\$23.2 M (2000)	\$0.5 M	N/A	23.4 M	N/A	\$0.99
Homestead Extension (HEFT) FL	\$0.06	No	\$0.25 – \$2.75	No	\$63.5 M (2001)	\$1.4 M	N/A	144 M	N/A	\$0.56
Polk Parkway FL	\$0.12 – \$0.21[3]	No	\$0.24 – \$3.00	No	\$10.2 M (2001)	\$0.5 M	N/A	12.8 M	N/A	\$0.80
Southern Connector, Greenville, SC	\$0.09 – \$0.25[3]	No	\$0.50 – \$1.50	No	\$2.6 M (2001)	\$0.2 M	3.5 M	N/A	\$0.75	N/A
SR-73 San Joaquin Toll Road Orange Co., CA	\$0.17 – \$0.20	Yes[1]	\$0.50 – \$3.00	No	\$60.7 M (2001)	\$4.0M	N/A	28.4 M	N/A	\$2.14
SR-261, SR-241 & SR-133 Foothill & Eastern Toll Roads Orange Co., CA	\$0.20 – \$0.25[3]	No	\$0.50 – \$4.50	No	\$83.5 M (2001)	\$1.5M	N/A	60.9 M	N/A	\$1.37

[1] Varies only for electronic toll collection [2] in U.S. dollars / mile [3] Variation due only to fixed tolls over different segment lengths

Figure 10 presents a comparison of the range of toll rates for the selected toll facilities to those develop for the regional network using a base value of time that is half the average wage. Unlike most facilities noted here, the regional network assumes toll rates that vary by time of day and by congestion levels. Furthermore, the facilities listed here have varying operating objectives, such as covering debt service or O&M costs, which tend to result in toll rates or time of day toll structures that are sub-optimal from the standpoint of revenue maximization or minimization of overall network travel times. Any range in the toll rate per mile for these facilities is typically a result of the unit distance tolled rather than intentional variation, with the exceptions of SR-91 and I-15. At the time of writing, SR-91's operating objective and toll structure are focused on revenue maximization.

Figure 10
Comparison of the Regional Network Toll Range
with Selected North American Toll Road Toll Ranges in 2001 $



NEXT STEPS

The focus of this study has been to identify the approximate range of annual revenue from tolling by examining the implementation of highway pricing region-wide. The regional modeling approach used employs the best currently available tools, and strikes a balance between technical methods and resource constraints. Optimal toll rate estimates and revenue forecasts resulting from this process represent initial or planning stage results, and are intended to inform decision-makers considering a myriad of infrastructure investments and possible funding sources. This fact suggests a number of possible next steps — from an analysis standpoint — that could be undertaken assuming that the preliminary revenue results, not to mention public interest, look sufficiently promising to warrant further consideration of region-wide or facility specific tolling.

First, additional toll research, modeling and revenue estimation work should be considered, ranging from additional modeling sensitivity testing and assumptions refinement to a much more involved process yielding "investment grade" traffic and toll revenue forecasts. Possible future work elements are described below.

Second, as part of the refinement of the traffic and revenue forecasts, consideration needs to be given to the operating objectives of tolling. In other words, is the objective to maximize revenue by creating relatively substantial time savings benefits for those most willing to pay, or is it to generate some revenue while maximizing network travel benefits by minimizing the collective travel time of all users. This issue is further discussed below.

Third, much more attention should be directed to the technological and policy considerations of toll collection, especially with consideration of a regional toll network. This effort should include an in-depth look at the toll collection capital investments, technology application, and ongoing operations, maintenance and administration costs. Ideally, this work would be done independently of any toll modeling and revenue refinement, but with shared assumptions regarding operations, especially if operating assumptions are altered in such as way as to potentially affect the revenue projections. As an element of the design process, this effort should also be subjected to the WSDOT Cost Estimation and Validation Process (CEVP).

Fourth, additional research and legal analysis would need to be undertaken to identify the Federal policies and State laws that would need to enacted or amended to facilitate regional tolling, particularly for existing interstate facilities and facilities not previously contemplated for tolling under existing State law.

Finally, the breadth and complexity of the capital projects that regional toll revenues may be required to support would necessitate a systematic financial analysis in order to identify the true leveraging capacity of annual toll revenues. The inability to simply suggest that each million dollars of toll revenue supports some multiplier of capital investment through bonding is primarily a function of timing and scale. Anticipating that construction of several mega-projects requires more than several years, and that toll revenues would not likely be fully available for debt service until the majority of network improvements are complete, may lower the financial capacity of the toll revenue stream and require other funding sources and financial tools to bring more funding "up front" with construction expenditures. The financial analysis would also need to include the toll collection capital investments as part of the overall project costs, and the ongoing operations costs would need to be subtracted from the annual toll revenue stream in order to identify the net revenues available for debt service.

Revenue Validation and Investment Grade Toll Revenue Forecasts

Assuming that toll revenues look promising and are intended to serve as a primary source of funds from which to borrow against and cover debt service costs (e.g., the sale of revenue bonds), then the successful issuance of debt will likely require completion of a more thorough, "investment grade" toll traffic and revenue forecast study.

What exactly defines "investment grade" toll traffic and revenue forecasts? In a simplistic sense, the answer is whatever revenue forecast assumptions, methods, and review procedures that are sufficiently conservative to instill the confidence of the bond rating agencies and financial markets.

Specifically, a minimum "investment grade" rating from one or more rating agencies is necessary to achieve reasonable financing terms and cost-effectively sell toll revenue bonds.[13] Rating agencies such as Standard and Poor, Moodys and Fitch evaluate the revenue sources that would be dedicated to the repayment of bonds in order to rate the risk associated with a particular issuance. A proposed issuance that receives a rating is considered investment grade, and the better the rating, the more marketable the securities are and the lower the interest rate paid by the borrower, all else equal. Bonds that backed by revenue sources with sufficient uncertainty that they do not to get rated are known as sub-investment grade or "junk" bonds. Such bonds can be difficult to market, and result in very high interest costs as investors demand a premium return commensurate with the risks of default.

In order to obtain an investment grade rating, an independent third party must prepare a detailed traffic and revenue study that addresses all of the pertinent issues related to the toll revenue, including the elasticity of demand, demographic inputs (an independent view of this separate from the MPO), toll rates, operations and maintenance costs, etc.[14] In addition, investment grade forecasts tend to be distinguished from preliminary or planning grade results by their more rigorous and critical deliberation of assumptions, methods and review procedures at all stages. Finally, they typically result in a very thorough and professional report combined and in-person meeting with the rating agencies.

The actual assumptions, methods and review procedures for an investment grade study are not proscribed — in fact, they can vary across projects and be subject to considerable debate — rather it is the thorough consideration of risk variation, examination of inputs, validation tests, high standards of quality, and independent review at every step of the process that tend to characterize investment grade results. It should also be noted that investment grade results involve much more time consuming and costly efforts than do the initial planning level

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[13] Financial assistance via the federal Transportation Infrastructure Finance and Innovation Act (TIFIA) also requires investment grade traffic and revenue forecasts.

[14] In the U.S. tax-exempt bond market, there are currently only a few firms that the rating agencies are willing to rely upon for these forecasts

forecasts. However, if the decision has been made to rely on toll revenues for a significant share of project funding, investment grade forecasts are warranted and will pay for themselves by conveying and reducing risks as well as facilitating and lowering the cost of project financing.

While the discussion of planning versus investment grade forecasts herein has concentrated on toll traffic and revenues, the distinction along with its associated review and validation processes apply to the projected revenue for any funding source for which project investment decisions will be made or financing will be secured.

Regional Toll Revenue Considerations

For the Puget Sound region, more detailed market research regarding the behavioral nature and characteristics of potential road users, including their willingness to pay tolls, is needed to inform investment grade forecasts. Similarly, extensive travel demand modeling with better tools are required to apply the results of such research and better estimate toll elasticities of demand. It is likely that investment grade results would require a development of an independent and specialized travel demand forecasting model, or further refinement and modifications to the existing PSRC regional travel demand model, in order to provide adequate capabilities to conduct detailed sensitivity analysis of various pricing and travel benefit combinations. Development of such a tool would require a variety of professionals with specialized skills and experience in which the following activities would likely be undertaken.

- **Detailed market research, most likely including a stated-preference survey (SPS) —** Market research would need to be conducted to identify and gauge travel market behavior, willingness to pay by trip purpose, frequency, and income range, preferences regarding time and travel benefit trade-offs, and socio-economic aspects. If an existing toll facility with similar characteristics to the proposed facility serves the same or similar markets, then it may be possible to use revealed preference and/or panel survey data of the existing toll facility user market to identify likely behavior for the proposed facility. However, since there are no other comparable toll facilities operating in the Puget Sound Region to allow for this, it is essential that some SPS research be undertaken. The resulting survey information is required to provide pertinent quantitative data on potential toll users' sensitivity with respect to willingness-to-pay, socio-economic characteristics, and other travel behavior attributes. SPS data may need to be pooled with other travel survey data already collected by PSRC.

- **Develop a toll mode choice model —** A toll mode choice model would need to be developed to allow more accurate simulation of travel behavior decisions with respect to pricing trade-offs in the travel forecasting process. This task will also involve using appropriate statistical techniques to estimate toll elasticities of demand for various market segments. Such a toll mode choice model has been recently developed for facilities in Houston and Orlando.

- **Integrate the toll mode choice model with the applicable travel demand model —** The toll mode choice model would then be implemented within either a newly developed travel demand forecasting model or a modified and refined PSRC model. This task may involve reliance on experience from toll operations in other regions across the country (e.g., Houston, Orlando, San Diego, etc.)

- **Model and estimate toll revenues and/or toll pricing structures —** Upon fully completing data collection and model development, toll revenue forecasts would be prepared and/or toll pricing structures would be estimated according to desired facility and network operating objectives (e.g., revenue maximization, economically efficient toll, throughput targets, etc.)
- **Independent Review and Documentation** — A panel of independent experts would be assembled to review and comment on the modeling process and forecast results, which may result in further refinements and process iteration to refine the estimates. A technical report would then be prepared to document above efforts, methodology and results in such a manner as to convey the level of conservatism and risks in the results and inform experts in the finance industry.

A key product of this process would be reliable estimates for the toll elasticity of demand over a range of toll rates, trip purposes, and user demographics. This would facilitate the development of an optimum pricing structure to serve the real world operating objective(s), as well as allow for sensitivity analyses testing of different pricing schemes.

Revenue Maximization versus Maximum Societal Benefits

Earlier in this report, several toll road operating objectives were presented and discussed. As roadway pricing receives additional attention and consideration as a source of funding and congestion management tool, policy-makers will need to deliberate the relative merits of these objectives. The primary debate centers upon whether or not tolls should be set to maximize revenue or at some lower level with the intent of maximizing the efficiency of the entire network by minimizing overall network travel time, or even potentially lower to maximize throughput on the individual facility. At first glance, the middle objective would appear to maximize societal travel benefits subject to the constraints imposed. Similarly, the former may cause a higher, sub-optimal level of diversion to arterial roads that increases overall system delay by transferring more delay to the un-priced roads than it provides in time savings for toll road users. And the latter could potentially over utilize the freeway system from an overall network efficiency standpoint. However, the issue is not quite as simple as it seems, since it depends on the linkage between the toll revenues and infrastructure investments. In other words, if one assumes that the level of investment is a function of the toll revenues, and that a higher level of investment provides additional travel benefits, then a detailed benefit-cost analysis may be needed to help understand the ramifications of various tolling objectives.

The investment grade traffic and toll revenue tools would also serve to help inform the toll road operating objective/toll policy debate.

KEY FINDINGS

- Travel levels on the highway network of King and South Snohomish Counties have reached critical levels relative to available capacity to make value pricing of this capacity a viable method to manage demand to prevent congestion and generate new revenue to fund transportation improvements.
  - Seven major highways in King and South Snohomish County totaling 131 miles were modeled as toll facilities for this study. This regional toll network differs from that included in Regional Transportation Improvement District (RTID) proposed by the County Executives of King, Snohomish, and Pierce Counties. Additional context information about the County Executives' proposal is included in the main report.
- Simulating tolls in the regional travel demand model for seven major highway facilities yields optimal toll rates that seek to *minimize overall network travel time* with the objective of economic efficiency. These toll rates are higher than those which would *maximize facility throughput* but lower than those which would *maximize toll revenue*.
  - The maximum throughput objective may sound appealing, but would likely be sub-optimal not only from a revenue standpoint, but also because it would spend more of the public's time at a higher total social cost to get the maximum number vehicles through than would result with a higher toll rate.
  - There may be cause to set tolls closer to revenue maximizing levels if other tolling objectives do not generate sufficient revenue to support the improvement expenditures.
- In the assumed year of implementation (2014), these toll rates range from 4¢ to 42¢ per mile in year of collection dollars, depending on the location, time of day and travel direction.
  - Peak period toll rates would typically average around 11¢ per mile, whereas off-peak toll rates would hover about 4¢ per mile.
  - The optimal toll rates will need to increase periodically due to both inflation and growing travel demand, if the roadway is to be managed to maintain optimal network results and avoid congested conditions. These toll increases will require that the operating objectives and management policies of the facility be well established and clearly communicated to the public and policy-makers. It may be useful to craft toll enabling legislation to allow the toll authority to set toll rates at the minimum levels designed to maintain a certain speed threshold.
- At the time of writing, general tolling of federally funded interstate highways is highly restricted. Implementation of any regional tolling concept would likely require that these restrictions be relaxed. There is some indication that this may occur in the next federal transportation funding authorization act.
- For 2014, the projected toll revenue is estimated to range from approximately $252 to $457 million per year in inflated dollars, depending on the underlying value of time assumption and various operating parameters, and before operating and maintenance expenses. This estimated annual range is expected to grow to between $535 and $955 million by 2030 assuming tolls escalate with demand growth and inflation.

- The top end of this range applies the base value of time ($11.83 per hour), includes weekend tolling, and tolls trucks at an average rate of three times the auto toll, but does not represent the revenue maximizing situation. The assumptions underlying the top end of this range are not overly optimistic.
- The bottom end of this range applies the low value of time ($7.89 per hour), excludes tolls on weekends, and toll trucks at an average rate of two times the auto toll. The assumptions underlying the bottom end of this range are fairly conservative.

- Implementation of tolls will cause travel demand on these facilities to decrease as those users whose cost of travel in time plus tolls exceeds the benefits from travel seek other options.
  - Some users will divert to other un-priced alternative routes, lower cost times of travel, closer destinations or lower cost modes (HOVs and transit). Others will eliminate their trips altogether or combine trips.
  - The model results may over-estimate the true diversion away from the toll facilities, which would tend to understate the optimal toll rates and toll revenue potential. Further research and model refinements would be needed to better understand diversion impacts, especially to the arterial street system.
- Assuming toll revenues were immediately available to begin debt service payments (not particularly relevant in this case of multiple projects of long construction duration), each $1 million of annual toll revenue, net of any operating costs, could leverage approximately $9-11 million of capital investment via the sale of municipal revenue bonds or similar debt instruments.
  - It may not be realistic to assume that toll revenues would be immediately available to service debt. However, a more realistic assessment of toll revenue financial capacity would require detailed information regarding the timing of other revenue sources, proposed debt instruments, construction costs and phasing, toll collection implementation and technologies, and a host of other factors (e.g., debt service coverage requirements, issuance costs, debt terms and duration, etc.) which would serve as input to a detailed financial analysis of regional highway investments.
- Additional policy and institution factors that need further consideration:
  - Potential diversion impacts to the arterial street network needs further study, including a detailed analysis of how diversion impacts arterials and consideration of local jurisdiction concerns and priorities.
  - Policy and legal issues regarding the tolling of existing facilities, be they interstate highways funded with federal dollars or facilities that do not receive improvements, need to be considered in the context of the interdependence of a regional toll network.
  - Further study of the technological and economic feasibility of implementing wide-spread electronic toll collection, including capital investment costs and ongoing operating, maintenance and administrative expenses, needs to be undertaken.
  - A detailed financial analysis is needed to gauge the appropriate capacity of the projected revenue stream for financing the system of proposed projects and related improvements.

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APPENDIX

Table A - 1
Toll Analysis Segments by Facility

Toll Facility & Analysis Segment	*Segment Distance (miles)*
SR-99	
Roy to Broad/Alaskan Wy	0.93
Broad/Alaskan Wy to Midtown ramps	1.09
Midtown ramps to 1st Ave ramps	0.57
1st Ave ramps to Spokane	2.34
Spokane to 1st Ave So	1.14
SR-509	
1st Ave So to SR 518	5.51
SR 518 to SR 99	4.41
SR 99 to I-5	1.83
I-5	
I-405 to 220th	3.35
220th to 175th	3.13
175th to Northgate	3.24
Northgate to Lake City*	2.30
Lake City to SR 520*	2.55
SR 520 to Mercer*	1.18
Mercer to Olive*	0.69
Olive to James*	0.86
James to I-90	0.70
I-90 to Michigan	3.30
Michigan to Pacific Hwy	3.29
Pacific Hwy to Southcenter	3.53
Southcenter to SR 516	5.31
SR 516 to 320th	5.32
320th to Pierce County border	4.32
** Includes I-5 Express Lanes*	
I-405	
I-5 to 124th	10.04
124th to SR 520	5.39
SR 520 to I-90	3.73
I-90 to Park	5.76
Park to SR 167	3.00
SR 167 to Southcenter	2.28
SR-167	
I-405 to 212th	3.88
212th to 15th	6.70
15th to Ellingston	3.48
I-90	
I-5 to Rainier	0.86
Rainier to 77th	3.60
77th to I-405	3.03
I-405 to SR 900	5.84
SR-520	
I-5 to Montlake ramps	1.57
Montlake ramps to 84th	2.95
84th to I-405	2.36
I-405 to NE 40th	3.21
NE 40th to SR 202	2.72

Table A - 2
Spectrum of Optimal Toll Rates for 2014 in 2000 Dollars
(Base Value of Time)

Toll Facility	Toll Distance	PM Peak Period — $ / mi			AM Peak Period — $ / mi			Off-Peak / Weekend — $ / mi		
		Minimum	Maximum	Average	Minimum	Maximum	Average	Minimum	Maximum	Average
SR-99	6.1	$0.03	$0.16	$0.08	$0.03	$0.16	$0.08	$0.03	$0.03	$0.03
SR-509	11.8	$0.03	$0.10	$0.06	$0.03	$0.10	$0.06	$0.03	$0.03	$0.03
I-5	43.1	$0.03	$0.24	$0.10	$0.03	$0.15	$0.07	$0.03	$0.03	$0.03
I-405	30.2	$0.03	$0.14	$0.08	$0.03	$0.08	$0.05	$0.03	$0.03	$0.03
SR-167	14.1	$0.03	$0.14	$0.09	$0.03	$0.11	$0.06	$0.03	$0.03	$0.03
I-90	13.3	$0.03	$0.19	$0.09	$0.03	$0.13	$0.06	$0.03	$0.03	$0.03
SR-520	12.8	$0.04	$0.31	$0.14	$0.03	$0.21	$0.09	$0.03	$0.05	$0.03
Network	**131.3**	**$0.03**	**$0.31**	**$0.09**	**$0.03**	**$0.21**	**$0.07**	**$0.03**	**$0.05**	**$0.03**

Note: All amounts in year 2000 dollars

Table A - 3
Spectrum of Optimal Toll Rates for 2014 in 2000 Dollars
(Low Value of Time)

Toll Facility	Toll Distance	PM Peak Period — $ / mi			AM Peak Period — $ / mi			Off-Peak / Weekend — $ / mi		
		Minimum	Maximum	Average	Minimum	Maximum	Average	Minimum	Maximum	Average
SR-99	6.1	$0.02	$0.11	$0.05	$0.02	$0.11	$0.05	$0.02	$0.02	$0.02
SR-509	11.8	$0.02	$0.07	$0.04	$0.02	$0.07	$0.04	$0.02	$0.02	$0.02
I-5	43.1	$0.02	$0.16	$0.07	$0.02	$0.10	$0.05	$0.02	$0.02	$0.02
I-405	30.2	$0.02	$0.09	$0.06	$0.02	$0.05	$0.03	$0.02	$0.02	$0.02
SR-167	14.1	$0.02	$0.10	$0.06	$0.02	$0.07	$0.04	$0.02	$0.02	$0.02
I-90	13.3	$0.02	$0.12	$0.06	$0.02	$0.09	$0.04	$0.02	$0.02	$0.02
SR-520	12.8	$0.03	$0.20	$0.09	$0.02	$0.14	$0.06	$0.02	$0.03	$0.02
Network	**131.3**	**$0.02**	**$0.20**	**$0.06**	**$0.02**	**$0.14**	**$0.04**	**$0.02**	**$0.03**	**$0.02**

Note: All amounts in year 2000 dollars

Table A - 4
Spectrum of Optimal Toll Rates for 2030 in Inflated Dollars
(Base Value of Time)

Toll Facility	Toll Distance	PM Peak Period — $ / mi			AM Peak Period — $ / mi			Off-Peak / Weekend — $ / mi		
		Minimum	Maximum	Average	Minimum	Maximum	Average	Minimum	Maximum	Average
SR-99	6.1	$0.07	$0.36	$0.20	$0.07	$0.36	$0.20	$0.06	$0.07	$0.06
SR-509	11.8	$0.07	$0.23	$0.16	$0.07	$0.23	$0.16	$0.06	$0.06	$0.06
I-5	43.1	$0.09	$0.62	$0.27	$0.06	$0.40	$0.17	$0.06	$0.11	$0.07
I-405	30.2	$0.06	$0.43	$0.25	$0.06	$0.25	$0.14	$0.06	$0.09	$0.06
SR-167	14.1	$0.12	$0.36	$0.24	$0.06	$0.27	$0.15	$0.06	$0.06	$0.06
I-90	13.3	$0.06	$0.47	$0.27	$0.06	$0.27	$0.16	$0.06	$0.09	$0.07
SR-520	12.8	$0.13	$0.87	$0.40	$0.06	$0.44	$0.23	$0.06	$0.16	$0.09
Network	**131.3**	**$0.06**	**$0.87**	**$0.26**	**$0.06**	**$0.44**	**$0.17**	**$0.06**	**$0.16**	**$0.07**

Note: All amounts in year of collection dollars

Table A - 5
Spectrum of Optimal Toll Rates for 2030 in Inflated Dollars
(Low Value of Time)

Toll	*Toll*	*PM Peak Period — $ / mi*			*AM Peak Period — $ / mi*			*Off-Peak / Weekend — $ / mi*		
Facility	*Distance*	*Minimum*	*Maximum*	*Average*	*Minimum*	*Maximum*	*Average*	*Minimum*	*Maximum*	*Average*
SR-99	6.1	$0.04	$0.24	$0.14	$0.04	$0.24	$0.14	$0.04	$0.05	$0.04
SR-509	11.8	$0.04	$0.16	$0.11	$0.04	$0.16	$0.11	$0.04	$0.04	$0.04
I-5	43.1	$0.06	$0.41	$0.18	$0.04	$0.27	$0.11	$0.04	$0.07	$0.05
I-405	30.2	$0.04	$0.29	$0.16	$0.04	$0.17	$0.09	$0.04	$0.06	$0.04
SR-167	14.1	$0.08	$0.24	$0.16	$0.04	$0.18	$0.10	$0.04	$0.04	$0.04
I-90	13.3	$0.04	$0.31	$0.18	$0.04	$0.18	$0.11	$0.04	$0.06	$0.05
SR-520	12.8	$0.09	$0.58	$0.27	$0.04	$0.29	$0.15	$0.04	$0.11	$0.06
Network	**131.3**	**$0.04**	**$0.58**	**$0.18**	**$0.04**	**$0.29**	**$0.11**	**$0.04**	**$0.11**	**$0.04**

Note: All amounts in year of collection dollars

Table A - 6
Spectrum of Optimal Toll Rates for 2030 in 2000 Dollars
(Base Value of Time)

Toll	*Toll*	*PM Peak Period — $ / mi*			*AM Peak Period — $ / mi*			*Off-Peak / Weekend — $ / mi*		
Facility	*Distance*	*Minimum*	*Maximum*	*Average*	*Minimum*	*Maximum*	*Average*	*Minimum*	*Maximum*	*Average*
SR-99	6.1	$0.03	$0.17	$0.10	$0.03	$0.17	$0.09	$0.03	$0.03	$0.03
SR-509	11.8	$0.03	$0.11	$0.08	$0.03	$0.11	$0.08	$0.03	$0.03	$0.03
I-5	43.1	$0.04	$0.29	$0.13	$0.03	$0.19	$0.08	$0.03	$0.05	$0.03
I-405	30.2	$0.03	$0.20	$0.12	$0.03	$0.12	$0.07	$0.03	$0.04	$0.03
SR-167	14.1	$0.05	$0.17	$0.11	$0.03	$0.13	$0.07	$0.03	$0.03	$0.03
I-90	13.3	$0.03	$0.22	$0.13	$0.03	$0.13	$0.07	$0.03	$0.04	$0.03
SR-520	12.8	$0.06	$0.40	$0.19	$0.03	$0.21	$0.11	$0.03	$0.07	$0.04
Network	**131.3**	**$0.03**	**$0.40**	**$0.12**	**$0.03**	**$0.21**	**$0.08**	**$0.03**	**$0.07**	**$0.03**

Note: All amounts in year 2000 dollars

Table A - 7
Spectrum of Optimal Toll Rates for 2030 in 2000 Dollars
(Low Value of Time)

Toll	*Toll*	*PM Peak Period — $ / mi*			*AM Peak Period — $ / mi*			*Off-Peak / Weekend — $ / mi*		
Facility	*Distance*	*Minimum*	*Maximum*	*Average*	*Minimum*	*Maximum*	*Average*	*Minimum*	*Maximum*	*Average*
SR-99	6.1	$0.02	$0.11	$0.06	$0.02	$0.11	$0.06	$0.02	$0.02	$0.02
SR-509	11.8	$0.02	$0.07	$0.05	$0.02	$0.07	$0.05	$0.02	$0.02	$0.02
I-5	43.1	$0.03	$0.19	$0.09	$0.02	$0.12	$0.05	$0.02	$0.03	$0.02
I-405	30.2	$0.02	$0.13	$0.08	$0.02	$0.08	$0.04	$0.02	$0.03	$0.02
SR-167	14.1	$0.04	$0.11	$0.08	$0.02	$0.08	$0.05	$0.02	$0.02	$0.02
I-90	13.3	$0.02	$0.15	$0.09	$0.02	$0.08	$0.05	$0.02	$0.03	$0.02
SR-520	12.8	$0.04	$0.27	$0.12	$0.02	$0.14	$0.07	$0.02	$0.05	$0.03
Network	**131.3**	**$0.02**	**$0.27**	**$0.08**	**$0.02**	**$0.14**	**$0.05**	**$0.02**	**$0.05**	**$0.02**

Note: All amounts in year 2000 dollars

Table A - 8
Annual Revenue by Facility for Selected Years — High End Estimates
(Constant 2000 Dollars)

Toll Facility	*Toll Distance*	*Year 2000 Dollars in Millions*			
		2014	*2020*	*2025*	*2030*
SR-99	6.1	$10.8 M	$11.4 M	$12.0 M	$12.8 M
SR-509	11.8	$14.7 M	$15.6 M	$16.4 M	$17.3 M
I-5	43.1	$138.3 M	$151.9 M	$165.6 M	$181.0 M
I-405	30.2	$87.0 M	$98.2 M	$109.5 M	$122.4 M
SR-167	14.1	$23.7 M	$25.7 M	$27.6 M	$29.6 M
I-90	13.3	$30.6 M	$34.4 M	$38.2 M	$43.2 M
SR-520	12.8	$29.3 M	$32.8 M	$36.2 M	$40.4 M
Network	**131.3**	**$334.3 M**	**$370.1 M**	**$405.5 M**	**$446.7 M**

Table A - 9
Annual Revenue by Facility for Selected Years — Low End Estimates
(Constant 2000 Dollars)

Toll Facility	*Toll Distance*	*Year 2000 Dollars in Millions*			
		2014	*2020*	*2025*	*2030*
SR-99	6.1	$6.2 M	$6.6 M	$6.9 M	$7.4 M
SR-509	11.8	$8.4 M	$8.9 M	$9.4 M	$10.0 M
I-5	43.1	$75.2 M	$83.1 M	$90.9 M	$99.7 M
I-405	30.2	$47.1 M	$53.8 M	$60.5 M	$68.1 M
SR-167	14.1	$13.1 M	$14.3 M	$15.4 M	$16.6 M
I-90	13.3	$17.6 M	$19.9 M	$22.2 M	$25.2 M
SR-520	12.8	$16.8 M	$18.9 M	$20.9 M	$23.4 M
Network	**131.3**	**$184.3 M**	**$205.5 M**	**$226.3 M**	**$250.3 M**

Table A - 10
Annual Vehicle Miles Traveled by Facility (with Tolls)

Toll Facility	Toll Distance	Millions of Vehicle Miles Traveled					
		2006	2013	2014	2020	2025	2030
SR-99	6.1	187 M	192 M	192 M	196 M	200 M	204 M
SR-509	11.8	260 M	267 M	268 M	275 M	281 M	287 M
I-5	43.1	2,212 M	2,299 M	2,312 M	2,390 M	2,458 M	2,528 M
I-405	30.2	1,577 M	1,658 M	1,670 M	1,742 M	1,806 M	1,872 M
SR-167	14.1	354 M	366 M	368 M	379 M	389 M	398 M
I-90	13.3	448 M	471 M	474 M	495 M	513 M	532 M
SR-520	12.8	334 M	345 M	347 M	357 M	366 M	376 M
Network	**131.3**	**5,372 M**	**5,598 M**	**5,631 M**	**5,836 M**	**6,013 M**	**6,197 M**

Table A - 11
Overall Average Daily Toll Rates by Year in Inflated Dollars

Toll Facility	Toll Distance	Year 2000 Dollars in Millions			
		2014	2020	2025	2030
SR-99	6.1	\$0.08 / mi	\$0.10 / mi	\$0.11 / mi	\$0.13 / mi
SR-509	11.8	\$0.07 / mi	\$0.09 / mi	\$0.11 / mi	\$0.13 / mi
I-5	43.1	\$0.08 / mi	\$0.11 / mi	\$0.13 / mi	\$0.15 / mi
I-405	30.2	\$0.07 / mi	\$0.09 / mi	\$0.11 / mi	\$0.14 / mi
SR-167	14.1	\$0.09 / mi	\$0.11 / mi	\$0.13 / mi	\$0.16 / mi
I-90	13.3	\$0.09 / mi	\$0.12 / mi	\$0.14 / mi	\$0.17 / mi
SR-520	12.8	\$0.12 / mi	\$0.15 / mi	\$0.19 / mi	\$0.23 / mi
Network	**131.3**	**\$0.08 / mi**	**\$0.11 / mi**	**\$0.13 / mi**	**\$0.16 / mi**

Table A - 12
Overall Average Daily Toll Rates by Year in Constant 2000 Dollars

Toll Facility	Toll Distance	Year 2000 Dollars in Millions			
		2014	2020	2025	2030
SR-99	6.1	\$0.06 / mi	\$0.06 / mi	\$0.06 / mi	\$0.06 / mi
SR-509	11.8	\$0.05 / mi	\$0.06 / mi	\$0.06 / mi	\$0.06 / mi
I-5	43.1	\$0.06 / mi	\$0.06 / mi	\$0.07 / mi	\$0.07 / mi
I-405	30.2	\$0.05 / mi	\$0.06 / mi	\$0.06 / mi	\$0.07 / mi
SR-167	14.1	\$0.06 / mi	\$0.07 / mi	\$0.07 / mi	\$0.07 / mi
I-90	13.3	\$0.06 / mi	\$0.07 / mi	\$0.07 / mi	\$0.08 / mi
SR-520	12.8	\$0.08 / mi	\$0.09 / mi	\$0.10 / mi	\$0.11 / mi
Network	**131.3**	**\$0.06 / mi**	**\$0.06 / mi**	**\$0.07 / mi**	**\$0.07 / mi**

Table A - 13
Historical and Projected Inflation
(Implicit Price Deflator for Personal Consumption)

Year	*Annualized Implicit Price Deflator Index*	*Annual Growth Factor*	*Annual Escalation Factor for Year 2000*
1996	1.0002		
1997	1.0195	1.0193	
1998	1.0302	1.0105	
1999	1.0472	1.0165	
2000	1.0750	1.0265	1.0000
2001	1.0952	1.0189	1.0189
2002	1.1057	1.0096	1.0286
2003	1.1297	1.0217	1.0509
2004	1.1555	1.0228	1.0749
2005	1.1815	1.0225	1.0991
2006	1.2072	1.0218	1.1230
2007	1.2345	1.0226	1.1484
2008	1.2620	1.0223	1.1740
2009	1.2905	1.0226	1.2005
2010	1.3202	1.0231	1.2281
2011	1.3530	1.0248	1.2586
2012	1.3902	1.0275	1.2932
2013	1.4300	1.0286	1.3302
2014	1.4705	1.0283	1.3679
2015	1.5127	1.0287	1.4072
2016	1.5569	1.0292	1.4484
2017	1.6047	1.0307	1.4928
2018	1.6582	1.0333	1.5425
2019	1.7167	1.0353	1.5969
2020	1.7819	1.0380	1.6576
2021	1.8253	1.0244	1.6980
2022	1.8701	1.0246	1.7397
2023	1.9172	1.0252	1.7834
2024	1.9661	1.0255	1.8290
2025	2.0162	1.0255	1.8755
2026	2.0681	1.0258	1.9238
2027	2.1228	1.0264	1.9747
2028	2.1793	1.0266	2.0273
2029	2.2377	1.0268	2.0816
2030	2.2980	1.0270	2.1377

FINAL DRAFT TECHNICAL MEMORANDUM

PRICING AND MANAGED LANES
Trans-Lake Washington Corridors

INTRODUCTION

The purpose of this memorandum is to provide technical information on the performance and evaluation of the transportation pricing and managed lane alternatives analyses for the Trans-Lake corridors. Much of this memorandum focuses on the three build alternatives currently being evaluated by the Trans-Lake Washington project, and how they interact with the I-90 corridor.

- Safety and Preservation Alternative (4 Lane Alternative)
- Added HOV Lane Alternative (6 Lane Alternative)
- Added HOV and GP Lanes Alternative (8 Lane Alternative)

Each of these alternatives were evaluated at a corridor level, under the assumption that the potential for a regional system of managed lanes and/or transportation pricing program may become part of a long-range plan for the Central Puget Sound Region. This is consistent with the Puget Sound Regional Council (PSRC) policy framework outlined in the "Destination 2030" regional plan.

This memorandum is organized into four sections. The first section of this memorandum presents a general description of the transportation pricing and managed lane alternatives that were modeled for the Trans-Lake corridor. The second section describes the modeling methodologies that were used in modeling the transportation pricing and managed lane alternatives, and includes the estimation of toll rates and revenue estimates for the Trans-Lake corridor. The third section describes and presents the performance of the transportation pricing and managed lanes alternatives. The fourth and final section provides conclusions from the analysis, and provides recommendations for the next steps to define a pricing and/or managed lane option for the SR 520 corridor.

TRANS-LAKE MANAGED LANE AND TRANSPORTATION PRICING ALTERNATIVES

A total of seven alternatives were modeled using PSRC's suite of travel demand models. Six of these were transportation pricing alternatives, while the seventh was a managed lane alternative.

Transportation Pricing Alternatives

The concept of Value Pricing, also known as peak period pricing has been used in this study. It entails tolls or user fees that vary with the level of congestion on a facility. The more congested a facility is, the higher is the toll or user fee to use that facility. The more expensive the toll, the lower will be the number of users willing to pay the toll, thereby managing congestion on the facility.

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Road user fees or tolls that vary with the level of congestion provide incentives to shift some trips to less congested routes (local arterials), or alternative modes (carpooling and transit), or trip chaining (combining trips), or eliminate the trip, or shift the trip to off-peak period times. Since, off-peak period is also tolled in our study, this shift would not occur in our analysis.

Value pricing can be implemented only with Electronic Toll Collection (ETC) technology. The user fees or tolls can change every five minutes, with enough lead time such that a traveler knows exactly how much will be charged upon entry to a facility. This option has become technically viable within the last few years, as applications in California (SR 91 and I-15) have successfully demonstrated.

The following provides a description of the six transportation pricing alternatives that were modeled using the toll estimation methodology described in the following section of this memorandum.

Safety and Preservation Alternative - 4 Lanes

1. **4 Lane Value Pricing Concept – Toll on SR 520:** AM, PM and Off Peak period value pricing on SR 520 from SR 202 to I-5. All users (SOV and HOV 3+) with the exception of transit will be subject to tolls. Since SOV and HOV users share the same lanes and are not physically separated, the value pricing modeling methodology used to estimate toll rates cannot differentiate between SOV and HOV users, hence, all users are tolled. However, this would not be the case in the real world, because Electronic Toll Collection (ETC) technologies that are currently available are capable of differentiating between SOV and HOV users, and thus can toll SOV only.

2. **4 Lane Value Pricing Concept – Toll on SR 520 and I-90:** AM, PM and Off Peak period value pricing on SR 520 from SR 202 to I-5 and I-90 from SR 900 (Issaquah) to I-5. All users (SOV and HOV 3+) on SR 520 will be tolled. Only SOV and HOV 2 will be tolled on I-90, while HOV 3+ will not be subject to toll. Transit will not be tolled on both SR 520 and I-90.

Added HOV Lane Alternative - 6 Lanes

3. **6-Lane Value Pricing Concept – Toll on SR 520**: AM, PM and Off Peak period value pricing on SR 520 from SR 202 to I-5. All SOV and HOV 2 users will be tolled, while HOV 3+ and transit users will not be tolled.

4. **6-Lane Value Pricing Concept – Toll on SR 520 and I-90:** AM, PM and Off Peak period value pricing on SR 520 from SR 202 to I-5 and I-90 from SR 900 (Issaquah) to I-5. All SOV and HOV 2 users will be tolled, while HOV 3+ and transit users will not be tolled.

Added HOV and GP Lanes Alternative - 8 Lanes

5. **8-Lane Value Pricing Concept – Toll on SR 520**: AM, PM and Off Peak period value pricing on SR 520 from SR 202 to I-5. All SOV and HOV 2 users will be tolled, while HOV 3+ and transit users will not be tolled.

6. **8-Lane Value Pricing Concept – Toll on SR 520 and I-90:** AM, PM and Off Peak period value pricing on SR 520 from SR 202 to I-5 and I-90 from SR 900 (Issaquah) to I-5. All SOV and HOV 2 users will be tolled, while HOV 3+ and transit users will not be tolled.

Managed Lane Alternative

The following provides a description of the managed lane alternative that was modeled using PSRC's suite of travel demand models:

Added HOV and GP Lanes Alternative – 8 Lanes

7. **8-Lane Managed Lanes Concept – 4 General Purpose (GP) Lanes + 4 Managed Lanes:** No pricing on the 4 GP lanes for SOV and HOV 2 users. HOV 3+ and transit users will not be tolled on the 4 managed lanes. HOV 2 users can "buy in" by paying a toll to use the HOV managed lanes. HOV 2 access to the HOV managed lanes will only be allowed at the following locations:

    - Montlake Blvd.
    - Bellevue Way/104th Avenue NE
    - I-405 (via HOV direct access ramps)
    - Vicinity of NE 32nd Street (direct HOV access ramps near Overlake)
    - SR 202 (East Terminus)

    The decision for providing limited access points for HOV 2 to "buy into" the corridor was dictated by the primary objective of maintaining uncongested travel conditions on the managed lanes, where transit speeds and reliability would not be compromised. Depending on the performance of the limited access points, and the amount of un-used capacity on the managed lanes, additional access points could then be identified along the corridor for HOV 2. If the managed lanes had un-used capacity still available, then SOV trips would be allowed to "buy into" the corridor. In such a case, the tolls for SOV to "buy into" the corridor would be set much higher than that for HOV 2 users.

METHODOLOGIES FOR MODELING TRANS-LAKE ALTERNATIVES

Travel Forecasting Analysis

The Puget Sound Regional Council (PSRC) four-county travel demand forecasting model was applied to forecast general traffic, carpool, and transit demand for transportation alternatives studied in the Trans-Lake corridor. The PSRC model is multimodal and captures both regional and corridor-level trip making. The current version of the PSRC model was updated/refined for use on the Trans-Lake Washington Study and Alaskan Way Viaduct (AWV) Project. The aim of the additional validation analysis to the current PSRC model was to achieve an acceptable level of accuracy at key screenline locations critical to the Trans-Lake and AWV projects. The objective of this effort was not to replace or supersede the already validated PSRC model, but to enhance its capabilities to produce more accurate forecasts in the areas under study. It is expected that the methodological components of this model (e.g., trip distribution, mode choice, and time-of-day analysis) will be replaced once the ongoing PSRC model improvement program is successfully completed. The additional PSRC model validation analysis performed by Parsons Brinckerhoff, Inc. for the Trans-Lake and AWV Projects has been documented in the *Travel Forecasting Model Validation Report for Base Year (1998), issued in February 2002.*

Once additional validation analysis was completed for the year 1998, the model was applied to produce future year 2030 baseline travel forecasts as well as forecasts for 6-Lane and 8-Lane Alternatives reflecting additional capacity on SR 520. The baseline forecast is referred to as the "No Action" Alternative and all other Alternatives are compared against it. The "No Action" Alternative includes only those transportation improvements that have committed funding. The main differences among the Alternatives were captured by changes in the highway and transit networks. The future highway and transit networks, representing each of the Alternatives, were developed using the same coding conventions as used in the 1998 network. Year 2030 travel forecasts were prepared using forecasted population and employment, parking costs, and other data from the PSRC, consistent with the 2030 Metropolitan Transportation Plan adopted in May 2001.

Travel Forecasting Analysis Managed Lanes Alternative

The updated PSRC model was used to produce travel forecasts for a managed lanes alternative on SR 520. The concept modeled included two managed lanes in addition to two lanes for general-purpose traffic in each direction. Access to the managed lanes was restricted to 2+HOVs during both peak and off-peak periods and at the planned direct access locations.

Value Pricing Sensitivity Analysis

As stated previously, the Puget Sound Regional Council's regional travel demand model and forecasting procedures were adapted for analyzing value pricing within the context of tolling limited access facilities. While these tools represent the best methods available for feasibility purposes, this work is at the edge of their intended application, and moreover, the timing is such that this work does not benefit from work-in-progress improvements to the regional model.

The value pricing methodology, developed for PSRC as part of the overall congestion pricing analysis performed during the 2030 MTP development process,[1] was used to perform the pricing sensitivity test for the Trans-Lake Alternatives. In theory, the mechanism by which tolls are simulated within the regional model is relatively simple. On an un-priced roadway, users consider only their own travel time costs, and not the delay costs their vehicle imposes on other users. This behavior tends to result in roadway over-consumption and congestion, especially during peak demand times. Optimal travel behavior – that which theoretically minimizes overall network travel time – could be induced by applying tolls that are equivalent to the incremental delay imposed on others, with the revenues used to make cost-beneficial transportation investments. This is referred to as the "economically efficient" toll.

The modeling approach employed seeks to internalize the external time cost or incremental delay that an additional vehicle imposes on all other vehicles in the traffic stream. When users are compelled to consider this additional cost, some users alter their travel behavior, resulting in lower highway volumes, and higher resulting speeds. As roadway demand increases, the economically efficient or optimal toll also rises at an increasing rate to maintain reasonable speed and flow conditions, by inducing a sufficient number of would-be road users to seek alternative routes, modes, or times to travel.

Model results from this methodology provided an estimate of potential traffic diversion and mode choice effects of pricing on SR 520 and/or I-90 under each Trans-Lake Alternative. This procedure also provides an estimate of pricing time costs that can be used to calculate an average toll rate for each time period on each Trans-Lake facility based on assuming a pertinent value for "willingness-to-pay" or travel time.

[1] Detailed descriptions are presented in the "Puget Sound Regional Council Transportation Pricing Alternatives Study – Technical Memorandum 3: Simulating Congestion Pricing in EMME/2," prepared by R. Pozdena, EcoNorthwest, February 19, 2000.

Estimation of Toll Rates

Estimated optimal toll rates are available from an analysis of value pricing on a system of limited access facilities in King County and southern Snohomish County undertaken for WSDOT Urban Corridor Office. The analysis, which was done in parallel with the evaluation of pricing and managed lanes for the Trans-Lake Washington Project, is described in *Regional Toll Revenue Feasibility Study, Draft Report*, July 2002. The regional modeling assumed the 6-lane alternative for SR 520, no improvements to I-90, and tolls applied to both facilities, as well as other major urban highways including I-5, I-405, SR 167, SR 509 and SR 99.

Optimal toll rates, expressed in time costs as minutes per mile, are derived from the model results – based upon the volumes and volume-to-capacity ratios for each roadway link in the model. Toll rates are aggregated to analysis segments and calculated by time period (AM peak, PM peak, and midday/evening off-peak) and direction of travel over a 15 hour portion of the day. The resulting toll time costs are then converted to monetary units by applying the average willingness to pay for delay reduction, expressed in dollars per hour. Research has shown that this value of time is approximately one-half of the average wage rate. For purposes of these analyses, the value of time was varied between one-third and one-half of the average wage rate for King County to create a range of monetary toll rates. The toll rates are expressed in inflated dollars escalated to the year of collection, and apply to single and two occupant vehicles. Three-plus occupant vehicles and transit vehicles are assumed to use HOV lanes at no charge or would otherwise be exempted from tolls. Trucks are tolled at a multiplier of the auto toll rates.

Tolls are assumed to be collected electronically throughout the regional toll network. The AM and PM peak periods would vary in timing and duration by facility and location, but in no cases are they less than three hours. Peak toll rates would vary noticeably by facility conditions, levels of congestion, and location to remain at their optimal levels. With reduced facility demand, the off-peak toll rates are generally lower. Off-peak tolls would apply to a midday window of time on weekdays, weekday evenings from 7 – 9 PM, and weekends from 6 AM – 9 PM. The network was assumed to be toll-free every day from 9 PM – 6 AM, both to give users an un-priced choice of travel, and also because, in most cases, traffic volumes are not high enough to generate optimal toll rates much above zero.

Application of the toll modeling methodology within the PSRC regional model results in modified traffic forecasts of vehicular travel within the general purpose lanes, and allows for the calculation of the optimal toll rates per mile by time period and analysis segment. Transit vehicles and 3+ HOVs using the toll-free HOV lanes are excluded from these traffic forecasts.

Results for value pricing these facilities individually would likely vary, but the differences may be small in the case of the cross-Lake Washington facilities. The toll modeling reported in this report resulted in volumes and congestion levels for a priced 6-lane Trans-Lake alternative (together with pricing on I-90) similar to those projected for the SR-520 and I-90 components in the *Regional Toll Revenue Feasibility Study*'s toll network modeling effort. This is primarily due to the fact that cross-Lake Washington travel is a somewhat captured market with few other reasonable alternatives.

Table 1 presents the 2014 and 2030 range of optimal toll rates per mile by time period and facility for a base value of time equal to one-half the average wage rate for King County, while Table 1a presents a range of optimal toll rates per mile for a low value of time equal to one-third the average wage rate for King County. Year 2014 is assumed as the year of project completion, and 2030 as the planning horizon year. The toll rates are expressed in year 2000 dollars and apply to single and two occupant vehicles. Transit and three-plus occupant vehicles are assumed to use toll-free HOV lanes, when available. Trucks are tolled at a multiplier of the auto toll rates.

Table 1: Weekday Toll Rate Estimates / Base Value of Time Equals 1/2 Wage Rate

Model Estimated Toll Rates (Year 2000 $) – 2014

Toll Facility	*Toll Distance*	*PM Peak Period — $ / mi*			*AM Peak Period — $ / mi*		
		Minimum	*Maximum*	*Average*	*Minimum*	*Maximum*	*Average*
I-90	13.3	$0.03	$0.19	$0.09	$0.03	$0.13	$0.06
SR 520	12.8	$0.04	$0.31	$0.14	$0.03	$0.21	$0.09

Note: All amounts are in year 2000 dollars and are based on a value of time of $11.83 / hour
SR 520 tolled sections include the entire facility
I-90 tolled sections extend from I-5 to SR 900 in Issaquah
Off peak toll rates range from 3¢ to 5¢ per mile

Model Estimated Toll Rates (Year 2000 $) – 2030

Toll Facility	*Toll Distance*	*PM Peak Period — $ / mi*			*AM Peak Period — $ / mi*		
		Minimum	*Maximum*	*Average*	*Minimum*	*Maximum*	*Average*
I-90	13.3	$0.03	$0.22	$0.13	$0.03	$0.13	$0.07
SR 520	12.8	$0.06	$0.40	$0.19	$0.03	$0.21	$0.11

Note: All amounts are in year 2000 dollars and are based on a value of time of $11.83 / hour
SR 520 tolled sections include the entire facility
I-90 tolled sections extend from I-5 to SR 900 in Issaquah
Off peak toll rates range from 3¢ to 7¢ per mile

Table 1a: Weekday Toll Rate Estimates / Low Value of Time Equals 1/3 Wage Rate

Model Estimated Toll Rates (Year 2000 $) – 2014

Toll Facility	*Toll Distance*	*PM Peak Period — $ / mi*			*AM Peak Period — $ / mi*		
		Minimum	*Maximum*	*Average*	*Minimum*	*Maximum*	*Average*
I-90	13.3	$0.02	$0.12	$0.06	$0.02	$0.09	$0.04
SR 520	12.8	$0.03	$0.20	$0.09	$0.02	$0.14	$0.06

Note: All amounts are in year 2000 dollars and are based on a value of time of $7.89 / hour
SR 520 tolled sections include the entire facility
I-90 tolled sections extend from I-5 to SR 900 in Issaquah
Off peak toll rates range from 2¢ to 3¢ per mile

Model Estimated Toll Rates (Year 2000 $) – 2030

Toll Facility	*Toll Distance*	*PM Peak Period — $ / mi*			*AM Peak Period — $ / mi*		
		Minimum	*Maximum*	*Average*	*Minimum*	*Maximum*	*Average*
I-90	13.3	$0.02	$0.15	$0.09	$0.02	$0.08	$0.05
SR 520	12.8	$0.04	$0.27	$0.12	$0.02	$0.14	$0.07

Note: All amounts are in year 2000 dollars and are based on a value of time of $7.89 / hour
SR 520 tolled sections include the entire facility
I-90 tolled sections extend from I-5 to SR 900 in Issaquah
Off peak toll rates range from 2¢ to 5¢ per mile

The following points should be noted in interpreting these toll rates in the context of the Trans-Lake transportation pricing alternatives analysis.

- If value pricing was implemented only on SR 520, then the travel cost of the I-90 alternative route could look relatively more favorable than if both crossings were value priced. This could lead to more diversion to I-90, and an equilibrium situation that results in lower volumes, and thus, lower V/C ratios and toll rates on SR 520 than shown in Table 1 and 1a.

- Because the toll rates in Table 1 and 1a are from a system-wide analysis of value pricing, in the absence of tolls on the other facilities, diversion from SR 520 and I-90 to drive-around options could be greater, and thus, actual maximum toll rates could be lower than those presented.

- ***Estimate of Average Toll on SR 520 – Base Value of Time Equals One-Half the Wage Rate.*** Assuming a maximum trip length of 12.8 miles on SR 520, the **average** toll for a one-way peak period trip across SR 520 from Redmond (SR 202) to Seattle (I-5) in 2014 (assumed year for implementing tolls) and 2030 is shown in Table 2. Average tolls for a one-way peak period trip from I-405 to I-5 (6.8 miles) is also provided. These values of toll are reported in year 2000 constant dollars.

- ***Estimate of Average Toll on I-90 – Base Value of Time Equals One-Half the Wage Rate.*** Assuming a maximum trip length of 13.3 miles on I-90, the **average** toll for a one-way peak period trip across I-90 from Issaquah (SR 900) to Seattle (I-5) in 2014 and 2030 is also shown in Table 2. Average tolls for a one-way peak period trip from I-405 to I-5 (7.3 miles) is also provided. These values of toll are also reported in year 2000 constant dollars.

Table 2: Average Toll for a One-way Trip (2000 Constant Dollars)
Base Value of Time (Equals 1/2 Wage Rate)

Facility	Trip Length	Average Toll in 2014	Average Toll in 2030
SR 520	12.8 miles (SR 202 to I-5)	$1.15 - $1.80	$1.41 - $2.43
	6.8 miles (I-405 to I-5)	$0.61 - $0.95	$0.75 - $1.30
I-90	13.3 miles (SR 202 to I-5)	$0.80 - $1.20	$0.93 - $1.73
	7.3 miles (I-405 to I-5)	$0.44 - $0.66	$0.51 - $0.95

- ***Estimate of Average Toll on SR 520 – Low Value of Time Equals One-Third the Wage Rate.*** Assuming a maximum trip length of 12.8 miles on SR 520, the **average** toll for a one-way peak period trip across SR 520 from Redmond (SR 202) to Seattle (I-5) in 2014 (assumed year for implementing tolls) and 2030 is shown in Table 2a. Average tolls for a one-way peak period trip from I-405 to I-5 (6.8 miles) is also provided. These values of toll are reported in year 2000 constant dollars.

- ***Estimate of Average Toll on I-90 – Low Value of Time Equals One-Third the Wage Rate.*** Assuming a maximum trip length of 13.3 miles on I-90, the **average** toll for a one-way peak period trip across I-90 from Issaquah (SR 900) to Seattle (I-5) in 2014 and 2030 is also shown in Table 2a. Average tolls for a one-way peak period trip from I-405 to I-5 (7.3 miles) is also provided. These values of toll are also reported in year 2000 constant dollars.

Table 2a: Average Toll for a One-way Trip (2000 Constant Dollars)
Low Value of Time (Equals 1/3 Wage Rate)

Facility	Trip Length	Average Toll in 2014	Average Toll in 2030
SR 520	12.8 miles (SR 202 to I-5)	\$0.77 - \$1.15	\$0.90 - \$1.54
	6.8 miles (I-405 to I-5)	\$0.41 - \$0.61	\$0.48 - \$0.82
I-90	13.3 miles (SR 202 to I-5)	\$0.53 - \$0.80	\$0.67 - \$1.20
	7.3 miles (I-405 to I-5)	\$0.29 - \$0.44	\$0.37 - \$0.66

Estimation of Toll Revenue

Revenue estimates for the tolling of a six-lane SR-520 over its entire 12.8 mile length without tolling I-90 have been developed as part of the Trans-Lake Washington Project and are presented herein. The procedures used for arriving at revenue estimates borrow from the economically efficient toll methods developed and applied in the *Regional Toll Revenue Feasibility Study* and the *Alaskan Way Viaduct Toll Feasibility Study*, but do not fully replicate all of these steps for various reasons.[2] In particular, the existing Trans-Lake toll modeling had not considered the simulation of the proposed highway improvements in the base year of 1999. This set of results would typically be necessary to provide an additional point in time to be compared with the future year in order to interpolate volumes and calculate toll rates revenues, and diversion results for intermediate years. In light of this and other constraints, a streamlined approach was developed that relies on some of the SR-520 toll assumptions and results of the *Regional Toll Revenue Feasibility Study* in order to generate revenue estimates for a stand-alone six-lane SR-520 toll facility.

The economically efficient toll methods essentially derive toll rates that approximate the external costs that an individual roadway user imposes on all other users by choosing to travel at a particular time and location. The toll rates are a function of the volume and capacity conditions that would exist after iteratively applying a modified volume-delay function in the modeling process to account for these external delay costs. The reader is referred to the *Regional Toll Revenue Feasibility Study* for a more detailed explanation of the optimal toll theory and application methods.

The streamlined approach undertaken dictates that toll revenue can only be reasonably estimated for the Trans-Lake alternative that matches the one modeled in the regional tolling study — the six-lane SR-520 configuration. Modeling results for 2030 with and without tolls on SR-520 only were used to estimate

[2] The *Alaskan Way Viaduct Toll Feasibility Study* is dated June 2002 and the *Regional Toll Revenue Feasibility Study (Working Draft)* is dated July 18, 2002. Both were prepared by Parsons Brinckerhoff for the WSDOT Office of Urban Corridors.

gross diversion rates and volume-to-capacity ratios, the latter which serve as inputs to deriving optimal toll rates by time period and direction. Upward adjustments were made to some of the resulting volume-to-capacity ratios for the following reasons. First, the Trans-Lake "without toll" model runs resulted in slightly lower volumes than did the regional toll study "without toll" model runs, particularly during the AM peak period, despite an expectation that they would be about the same. Second, the toll modeling methods used, when applied to a limited one-facility toll network, tend to be more likely to overstate gross diversion in the "with toll" case, and thus, understate revenue, than when tolling is more widespread. Finally, additional model runs to further refine the Trans-Lake toll modeling results to better match the procedures applied in modeling the regional toll network were not possible at this time.

Assumptions regarding the range for the value of time, the time-of-day distribution of traffic, percentage of traffic within the 15-hour toll period, the percentage of trucks by time period, and weekday to weekend factors, among others, were borrowed from the *Regional Toll Revenue Feasibility Study*. Using these assumptions and the calculation tools developed for the regional tolling analysis, a range of revenue was estimated for the stand-alone six-lane SR-520 toll facility.

The range of revenue varies from:

- a "low end" estimate that excludes weekend tolling, uses a relatively low 2x toll multiplier for trucks, and applies a conservative low value of time at one-third the average wage rate;

- to a more likely "high end" value that includes weekends at the off-peak toll rates, a 3x toll multiplier for trucks, and a base value of time at one-half the average wage rate.

This range of revenue was then compared to SR-520's share of 2030 revenue from the regional tolling analysis, and the resulting relationships were used in combination with the 2014 regional tolling revenue estimate for SR-520 to also obtain a 2014 revenue estimate for the stand-alone toll facility.[3]

Findings and results from the revenue analysis of value pricing travel on SR 520 are as follows.

- The 2030 revenue estimate for a stand-alone SR-520 represents 77% of the revenue generated by SR-520 under the regional toll network.

- From a traffic standpoint, the stand-alone toll facility carries 93% of the tolled vehicle miles that are accommodated by SR-520 in the regional toll network (measured over the 15-hour weekday toll period and weekends where applicable).

- Both of these results are expected — in the absence of tolling on I-90 (and I-5/I-405 for that matter), there is more of an incentive for some SR-520 users to divert to I-90 to avoid the toll. Because the optimal toll rate rises exponentially with traffic volumes, 7% lower traffic volumes actually result in 23% lower toll revenues.

- The average toll period gross diversion for SR-520 as a stand-alone toll facility is 23.1%, compared to 18.5% when part of a regional toll network. Gross diversion rates include those travelers who shift modes to transit or HOVs (carpools) and continue to use the facility at the same time.

[3] The base value of time is $11.89 per hour and the low value of time is $7.89 per hour, in 2000 dollars.

Applying the 77% revenue factor to the 2014 regional toll revenue estimates for SR-520 yields an estimated range of toll revenue for SR-520 as a single toll facility. This range approximates the revenue estimates that would likely have resulted with the full application of the toll feasibility methods to a stand-alone six-lane SR-520 toll facility. The revenue range for a stand-alone six-lane SR-520 toll facility is reported in Table 3 for both 2014 and 2030 in inflated, year of collection dollars.

Table 3: Range of Toll Revenue Estimates for a Six-Lane SR-520 Facility

Year	*SR-520 Toll Distance (miles)*	*SR-520 Annual Revenue Range (Inflated Dollars)*	
		LOW END: Low Value of Time Weekends Toll-Free 2x Truck Toll Factor	*HIGH END: Base Value of Time Weekend Tolling 3x Truck Toll Factor*
2014	12.8	$17.7 M	$30.9 M
2030	12.8	$38.4 M	$66.7 M

PERFORMANCE AND EVALUATION OF TRANPORTATION PRICING AND MANAGED LANE CONCEPTS

This section summarizes the transportation performance of the six transportation pricing and one managed lanes concept for the SR 520 corridor. Five mobility criteria were developed for use in the evaluation of these concepts. They are as follows:

- vehicle throughput
- person throughput
- traffic diversion
- volume to capacity (V/C) ratios and speeds
- mode shares

These criteria provide measures of the relative contributions of pricing and managed lanes on the SOV, HOV, and transit trips on the Trans-Lake corridor. It should also be noted that the information presented in this section is an evaluation of the relative performance of the alternatives under each mobility criteria and should not be considered as a representation of the absolute performance of any single pricing alternative.

The Puget Sound Regional Council's travel demand forecasting model was the primary information source for modeling the impacts of pricing and managed lanes on the SR 520 corridor. The PSRC model forecasts daily and peak period travel demand for the corridor in the year 2030. The model forecasts person trips and vehicle trips, and also provides information on travel speeds, volume to capacity ratios, and mode of travel. The model also provides information on any diversion of traffic caused by the introduction of tolls for crossing Lake Washington. The relative performance of the pricing and managed lanes concepts under each mobility criteria is discussed below.

Evaluation of Value Pricing Concepts

The evaluation of the transportation pricing alternatives focuses on 2030 travel conditions under two sets of pricing assumptions:

1. Peak period tolls on SR 520 Only – for the full length of the corridor (see Table 2 and Table 2a for average toll rates)

2. Peak period tolls on SR 520 and I-90 – for the full length of the corridor (see Table 2 and Table 2a for average toll rates)

The extent of the analysis is limited to an evaluation of cross-Lake Washington traffic patterns across a screenline that represents the following three facilities:

- SR 520 (Lake Washington Bridge)
- I-90 (West Bridge)
- SR 522 (West of 61st Avenue NE)

Presented below is a detailed evaluation of cross-Lake Washington traffic patterns for the 4, 6, and 8 Lane alternatives under the two pricing concepts. This includes an analysis of person throughput, vehicle throughput, traffic diversion, V/C ratios and speeds, and mode shares for each of the Trans-Lake alternatives.

Person Throughput

The total travel demand of daily person trips on the three facilities for the two pricing concepts is illustrated in Figures 1, 2, and 3. These figures summarize the total daily person trip activity and compares daily travel demand on SR 520, I-90, and SR 522 across the three different alternatives (4 Lane, 6 Lane and 8 Lane) under the "No Toll" and Toll scenarios. The Appendix to this report provides detailed forecasts of person trips by mode of travel for the different alternatives under the "No Toll" and Toll scenarios.

Observations – Toll on SR 520 Only

Irrespective of the number of lanes on SR 520, the application of toll on SR 520 results in a general reduction of 10% to 15% of the daily person trips using SR 520. On the other hand, both I-90 and SR 522 show increases in daily person trip activity. I-90 increases are between 5% to 9%, while SR 522 show increases of 3% to 5%.

Observations – Toll on SR 520 and I-90

The application of value pricing on both SR 520 and I-90 shows reductions in daily person trip activity across both SR 520 and I-90, while SR 522 shows increases. Both SR 520 and I-90 show decreases of 6% to 12%, while SR 522 shows corresponding increases of 5% to 15% in daily person trip activity.

Summary

The introduction of value pricing on Lake Washington crossings leads to an overall 6% - 15% reduction in daily person trips crossing Lake Washington. On the other hand, SR 522 shows increases in daily person trip activity ranging between 5% and 15%. To conclude, the introduction of tolls to SR 520 and/or I-90 results in a reduction of total person throughput across Lake Washington.

Figure 1
Daily Person Trip Comparison on SR-520

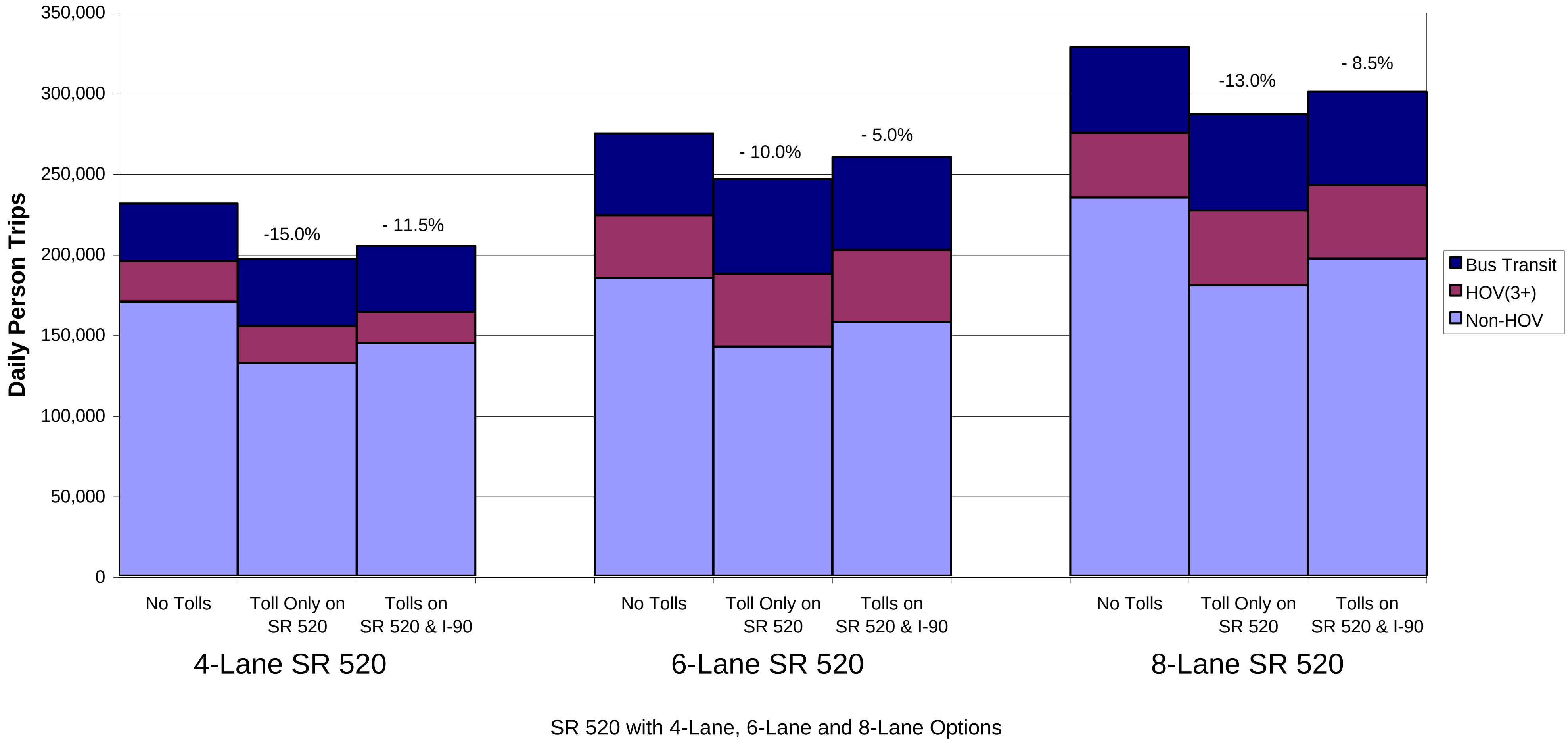


Figure 2
Daily Person Trip Comparison on I-90

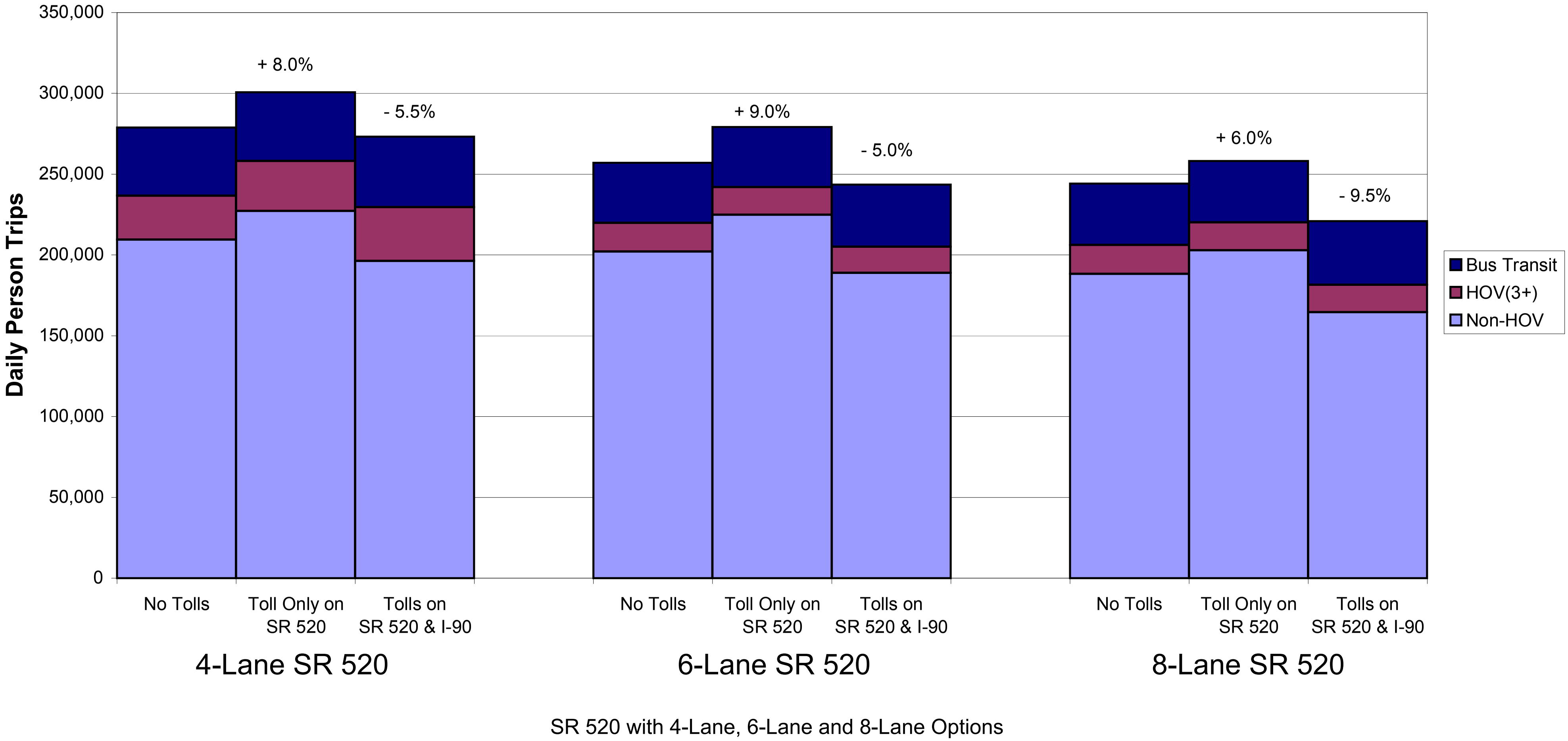
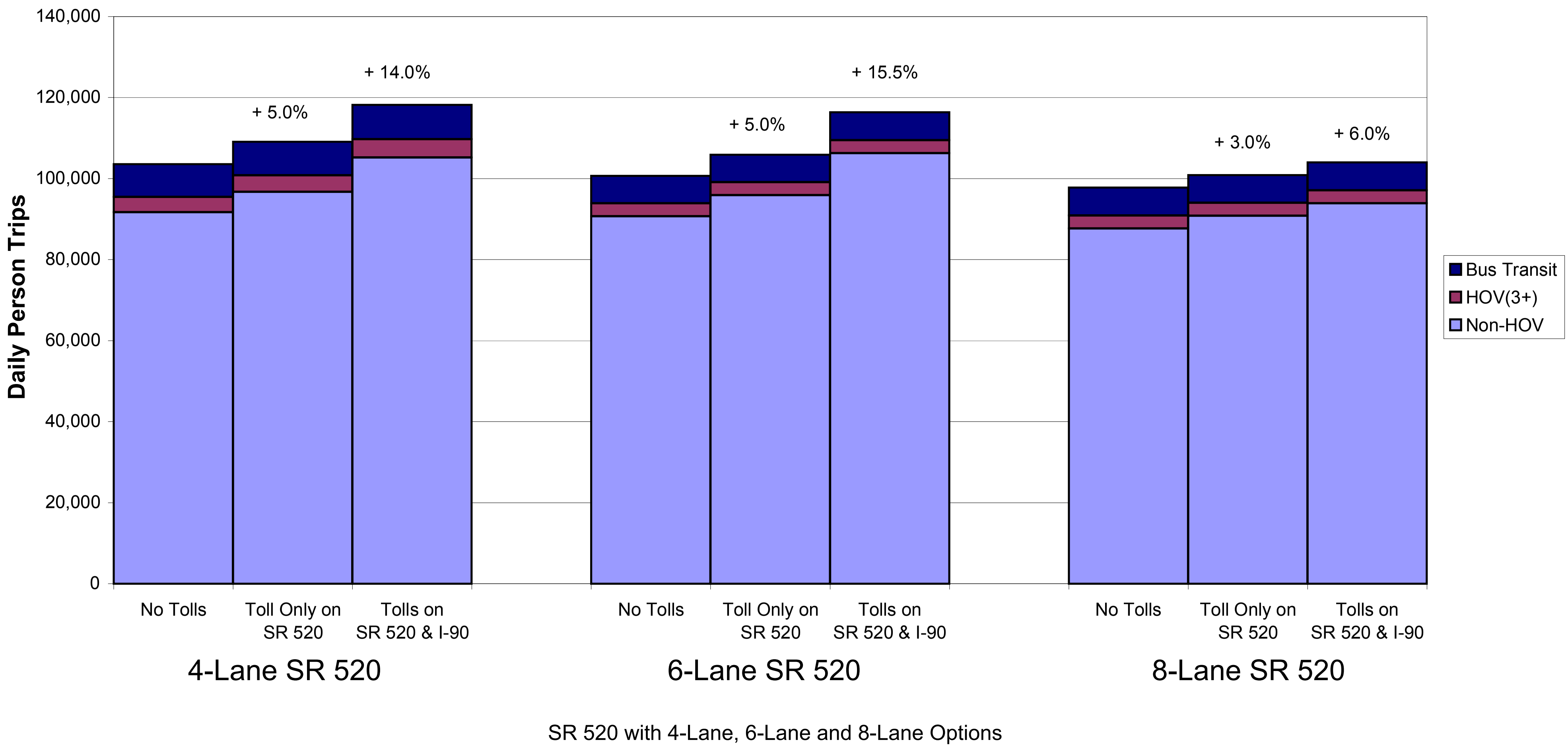


Figure 3
Daily Person Trip Comparison on SR-522



Vehicle Throughput

The total demand for vehicular trips on the three facilities for the two pricing concepts is illustrated in Figures 4, 5, and 6. These figures summarize the total daily HOV and non-HOV (SOV) vehicle trip activity and compares daily vehicular travel demand on SR 520, I-90, and SR 522 across the three different alternatives (4 Lane, 6 Lane and 8 Lane) under the "No Toll" and Toll scenarios. The Appendix to this report provides detailed forecasts by mode of travel for the different alternatives under the "No Toll" and Toll scenarios.

Observations – Toll on SR 520 Only

Non-HOV Trips - irrespective of the number of lanes on SR 520, the application of tolls on SR 520 results in a reduction of about 23% of the daily non-HOV trips using SR 520. On the other hand, I-90 shows increases of between 8% and 11% in non-HOV trip activity, and SR 522 also increases of about 4% to 6%.

HOV Trips – tolls on SR 520, result in an increase of almost 17% of HOV trips on SR 520. HOV trips on I-90 decrease by about 4%, while SR 522 shows no change in HOV trip activity.

Observations – Toll on SR 520 and I-90

Non-HOV Trips - the application of tolls on both SR 520 and I-90 show reductions in daily non-HOV trips across both SR 520 and I-90, while SR 522 shows an increase in SOV trip activity. SR 520 shows the most reduction of SOV trips, in the order of 14% to 16%, while, I-90 shows a reduction of between 6% and 12%. On the other hand, SR 522 shows an increase in non-HOV trip activity ranging between 7% and 17%.

HOV Trips – tolls on both SR 520 and I-90 result in an increase of between 13% and 15% of HOV trips on SR 520, while I-90 shows a decrease of between 5% and 9% in HOV trip activity. SR 522 shows no change in HOV trip activity.

Summary

The introduction of value pricing on Lake Washington crossings leads to an overall reduction of between 16% and 23% of non-HOV trips on SR 520 and I-90, while, SR 522 shows increases in non-HOV trips ranging from 4% to 17%. With respect to HOV trips, SR 520 experiences increases ranging between 13% and 17% in HOV trip activity, while, I-90 shows a decrease of about 5% to 9% in HOV trip activity, and SR 522 shows no change.

To conclude, the introduction of tolls result in a reduction of non-HOV trips crossing the Lake on SR 520 and I-90, accompanied by an increase in SOV trips going around the Lake on SR 522. There is also an increase in the total number of HOV trips crossing the Lake on both SR 520 and I-90, with SR 520 being the preferred crossing for the majority of HOV trips.

Figure 4
Daily Vehicle Trip Comparison on SR-520

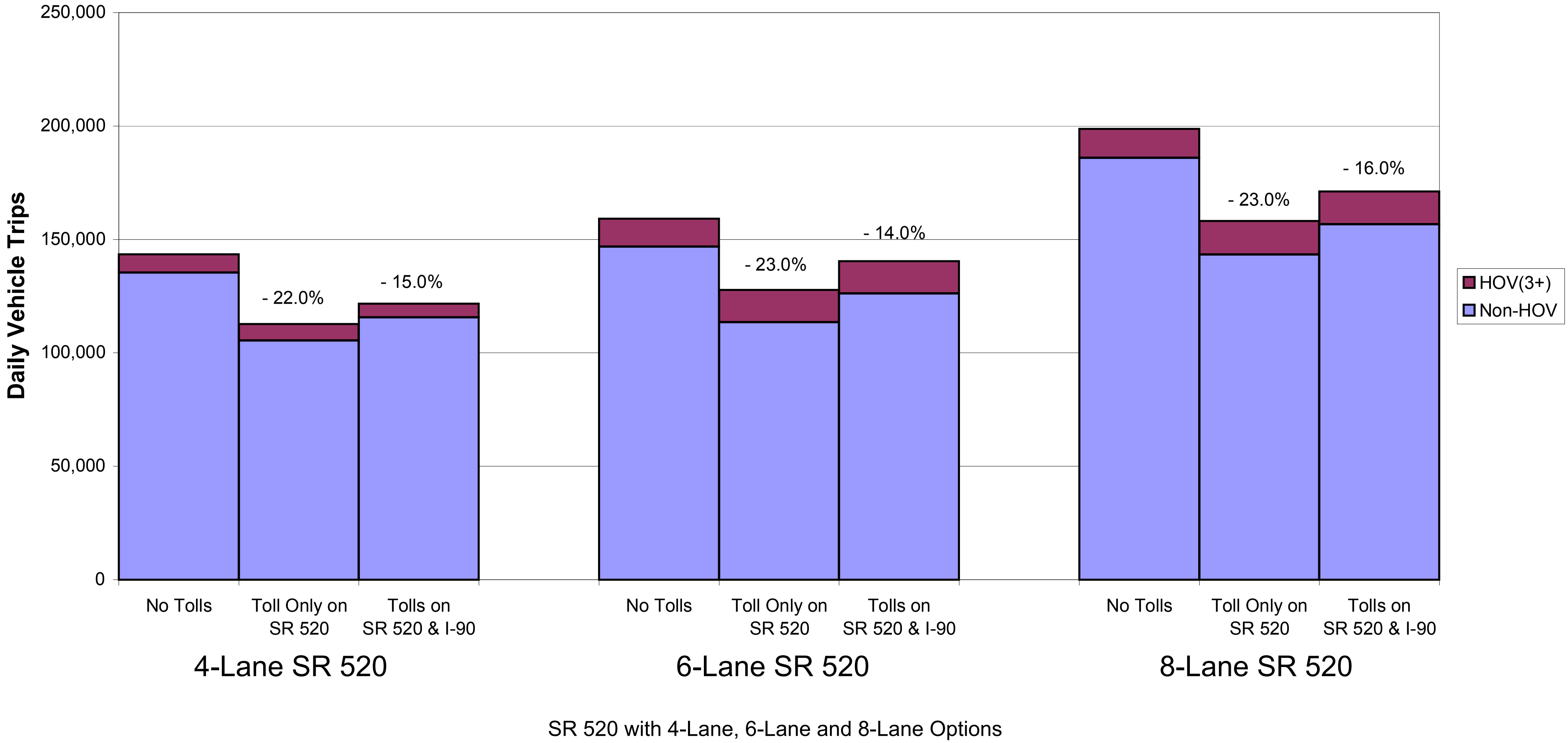


Figure 5
Daily Vehicle Trip Comparison on I-90

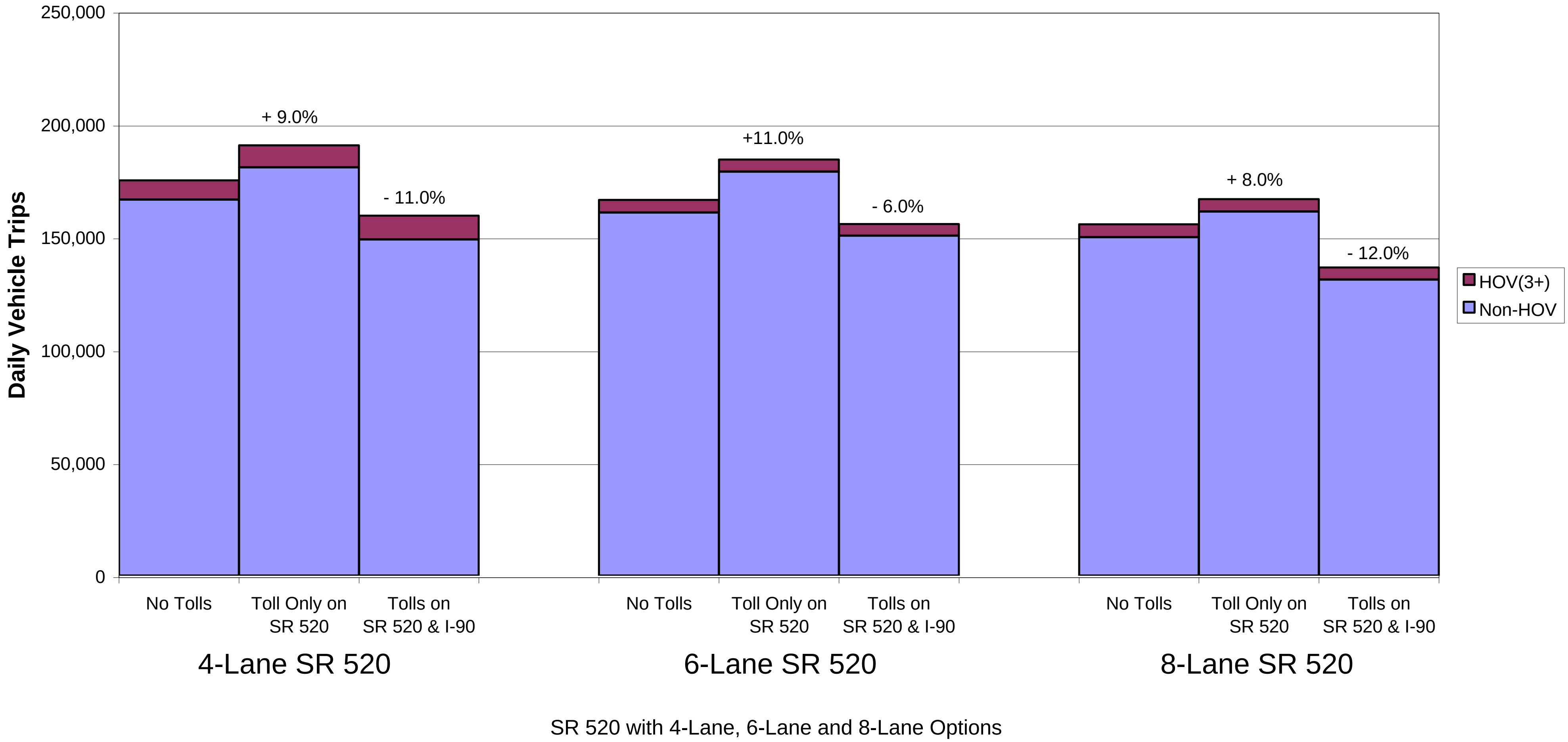
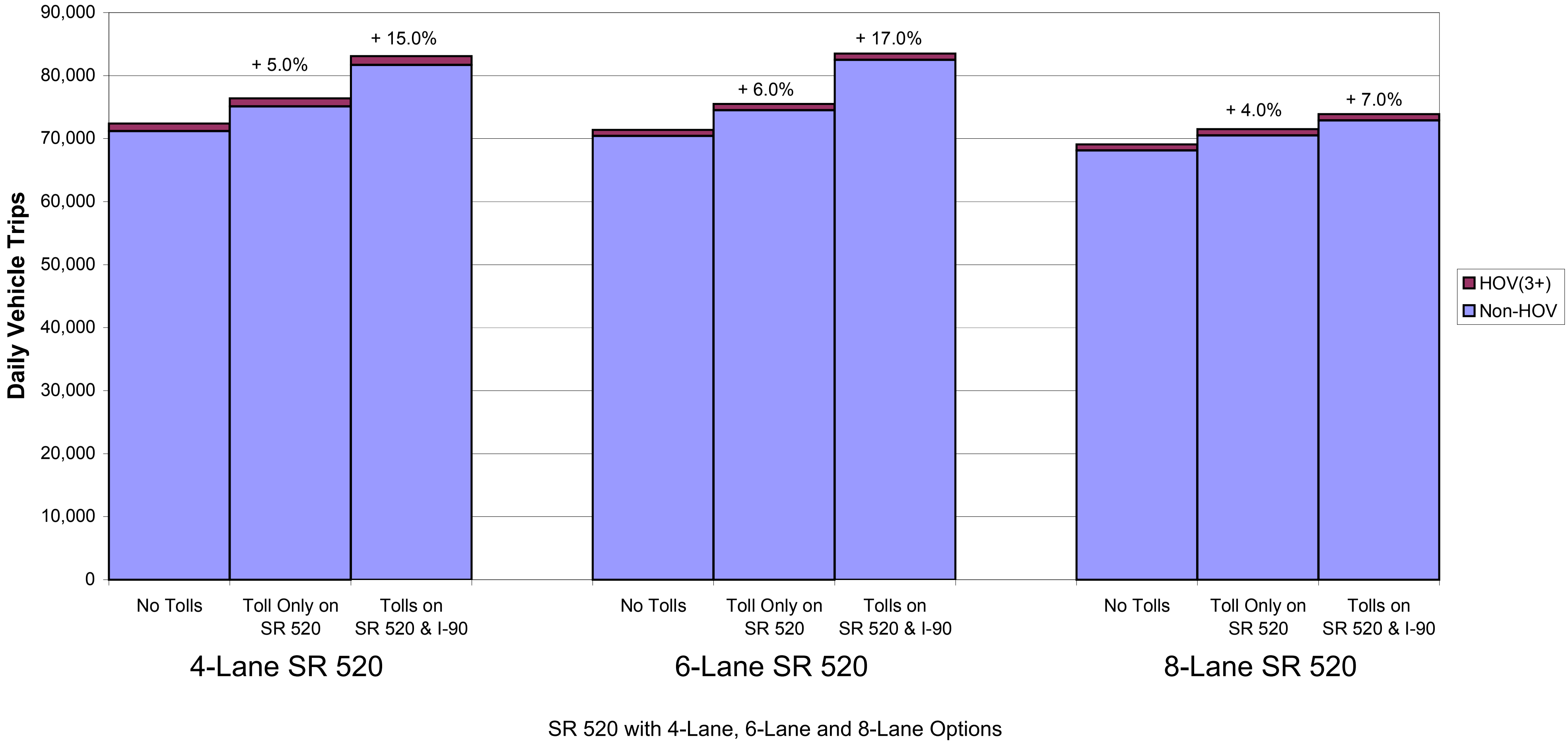


Figure 6
Daily Vehicle Trip Comparison on SR-522



Traffic Diversion

Changes in the daily travel pattern of vehicular trips are presented in Figures 7 and 8. Figure 7 illustrates the daily travel patterns of vehicular trips resulting from the application of tolls on SR 520, while Figure 8, illustrates the daily travel patterns resulting from the application of tolls on both SR 520 and I-90. It should be noted that these changes in daily travel patterns are based on a comparison of model results from the “No Toll” and “Toll” scenarios respectively.

Observations – Toll on SR 520 Only

Daily Travel Patterns - irrespective of the number of lanes on SR 520, the application of tolls on SR 520, result in a reduction of almost 20% of the daily vehicle trips on SR 520, as shown in Figure 7. In addition to the general reduction of trips on SR 520, the following daily traffic patterns results from value pricing SR 520 only:

- 9% increase in vehicle trips on I-90;
- 6% increase in vehicle trips on SR 522;
- 1% to 2% increase in vehicle trips on I-405 (south of the Trans-Lake corridor); and,
- 3% to 5% increase in vehicle trips on arterial roadways in Seattle, Bellevue, Kirkland, Redmond, and the Points Communities.

Observations – Toll on SR 520 and I-90

Daily Travel Patterns - irrespective of the number of lanes on SR 520, the application of tolls on SR 520 and I-90, result in a reduction of nearly 13% to 14% of the daily vehicle trips on I-90 and SR 520, as shown in Figure 8. In addition, the following daily traffic patterns results from value pricing SR 520 and I-90:

- 7% to 17% increase in vehicle trips on SR 522;
- 3% to 5% increase in vehicle trips on I-405 (south of the Trans-Lake corridor); and
- 5% to 10% increase in vehicle trips on arterial roadways in Seattle, Bellevue, Kirkland, Redmond, and the Points Communities.

Summary

The introduction of value pricing on SR 520 and I-90 results in an increase of 7% to 17% of the daily vehicle trips on SR 522, accompanied by a 3% to 10% increase in daily vehicle trips on arterial roadways in Seattle, Bellevue, Kirkland, Redmond, and the Points Communities.

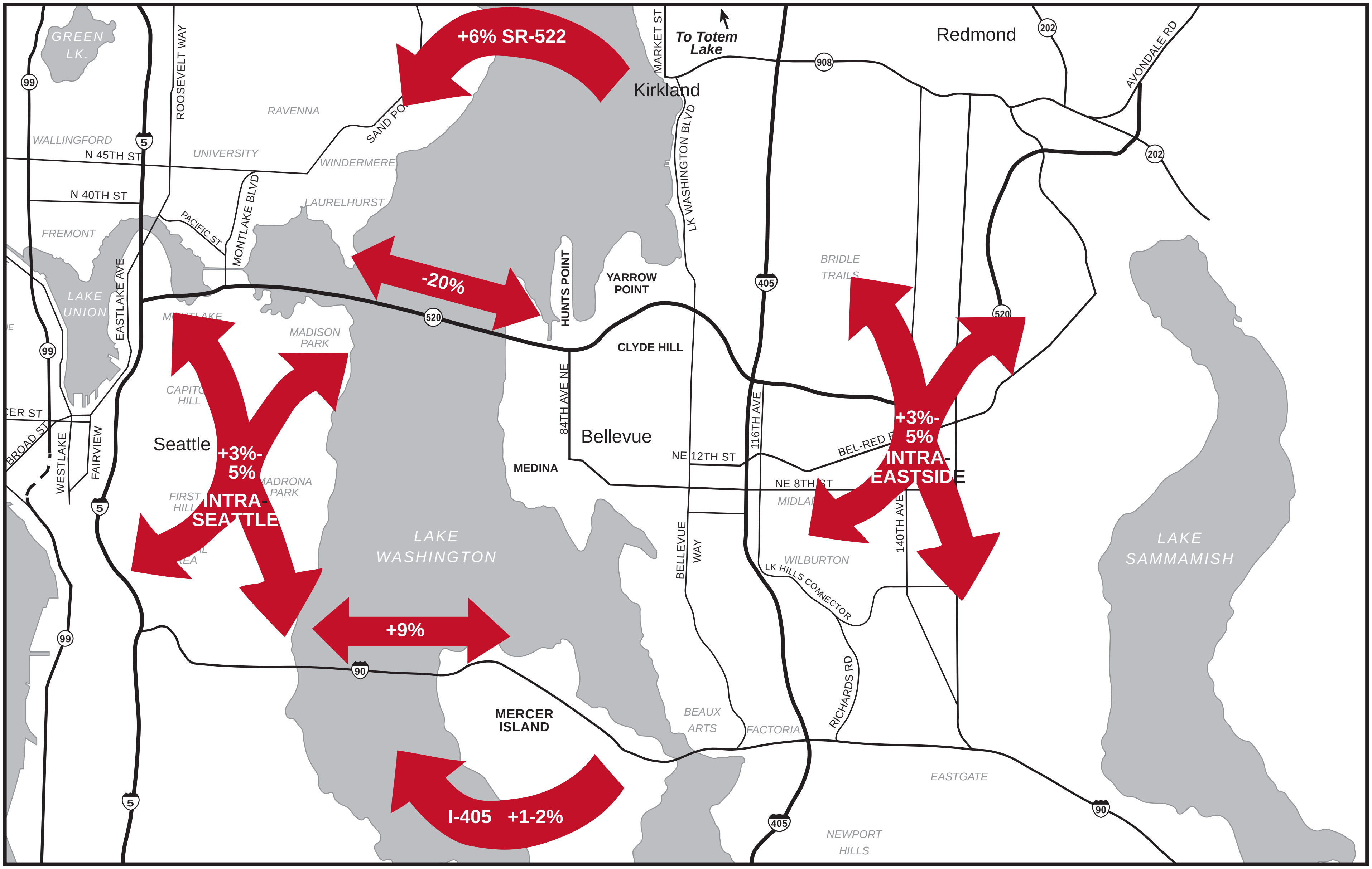


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Figure 7
Daily Travel Pattern Changes
Pricing on SR-520

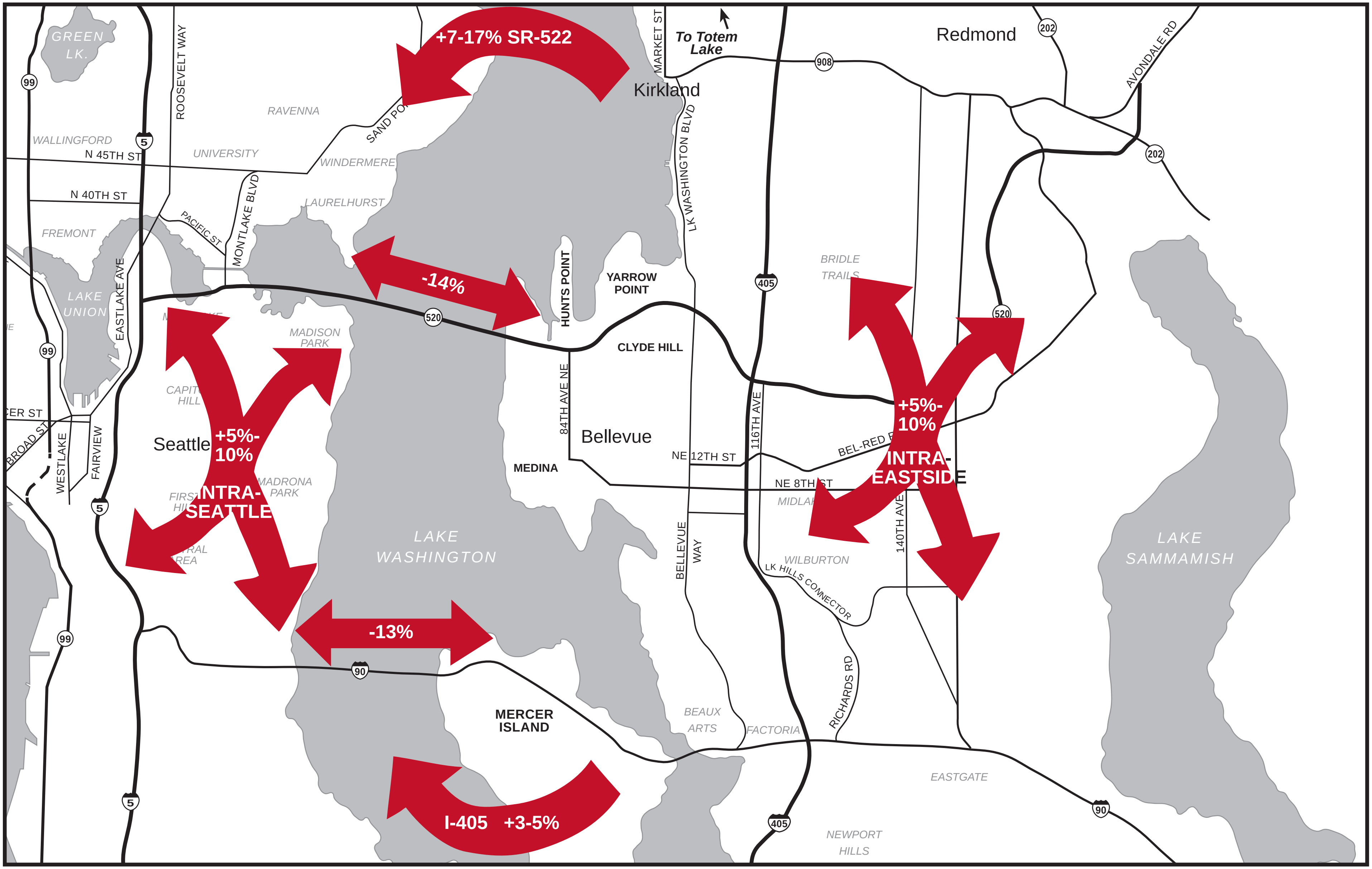

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Figure 8
Daily Travel Pattern Changes
Pricing on SR-520 & I-90

Volume to Capacity (V/C) Ratios and Speeds

The following is a discussion on changes in volume to capacity (V/C) ratios and operating speeds on the Lake Washington bridge under the "No Toll" and Toll conditions. Figures 9 thru 17, display changes to V/C ratios and operating speeds for the 4, 6, and 8 Lane alternatives.

Calculation of V/C Ratios and Speeds

The V/C ratios and speeds for the SR 520 bridge under the 4, 6, and 8 Lane alternatives was calculated based on the following assumptions:

- 2030 daily traffic forecasts for the 4, 6, and 8 Lane alternatives under the "No Toll" and "Toll" conditions served as the starting point for this analysis.
- Existing daily traffic volume distribution on SR 520 (near 76th Street) was used to generate the future hourly traffic volume distribution for the general purpose lanes and the HOV lanes.
- The 4 Lane alternative assumes a lane capacity of 2000 vehicles per hour for the general purpose lanes under the 4 Lane alternative.
- The 6 Lane alternative assumes a higher lane capacity of 2100 vehicles per hour. The added capacity reflects improvements to the SR 520 bridge, i.e., shoulder width, standard lane width, and improved sight distance.
- The 8 Lane alternative assumes a lane capacity of 2200 vehicles per hour per lane. In this case a slightly higher capacity per lane was assumed to take into account the two additional lanes that are being considered on the SR 520 bridge, in addition to the standard improvements to shoulder width, lane width, and improved sight distance.
- A HOV lane capacity of 1800 vehicles per hour for the 6 and 8 Lane alternatives.
- Buses were converted to passenger car equivalents (PCE) and added to the general purpose lane volumes under the 4 Lane alternative, and to the HOV lane volumes for the 6 and 8 Lane alternatives.
- A PCE conversion factor of 3.1 was used. This assumes 50 percent of the buses to be articulated with a PCE of 4 and the remainder to be single unit buses with a PCE factor of 2.2.
- 2030 general purpose traffic volumes were converted to PCEs assuming 5% heavy vehicles with a PCE factor of 2.2.

Observations – Toll on SR 520 Only

Figure 9 presents V/C ratios and operating speeds on the Lake Washington bridge for the 4 Lane alternative under the "No Toll" scenario, while Figure 10 presents the same information under toll conditions. Introduction of tolls on SR 520 shows a 20% reduction in V/C ratios (from 1.40 to 1.10) during the peak periods, resulting in an increase in operating speeds from below 10 mph to about 20 mph. A similar reduction in V/C ratios (from 1.15 to 0.90) is observed during the off-peak period, with operating speeds improving from 10 mph to 60 mph.

Similar trends in V/C ratios and operating speeds are observed with the 6 Lane alternative. Figures 12 and 13 present changes in V/C ratios and speeds from the 6 Lane alternative. Tolls on SR 520 result in a 24% reduction in V/C ratios during the peak periods (from 1.25 to 0.95), with operating speeds on the general purpose lanes increasing from below 10 mph to 55 mph during peak period conditions. During the off-peak period the V/C ratios drop by about 22% (from 1.15 to 0.90) and operating speeds on the general purpose lanes improve from below 20 mph to 60 mph.

The 8 Lane alternative shows trends in V/C ratios similar to the 4 and 6 Lane alternatives, however, the improvement to operating speeds are not as much as that observed with the 4 and 6 Lane alternatives. Figures 15 and 16 present changes in V/C ratios and speeds from the 8 Lane alternative. In this case, tolls on SR 520 result in a 20% reduction in V/C ratios during the peak periods (from 1.00 to 0.80), with operating speeds on the general purpose lanes improving from 45 mph to 60 mph. During the off-peak period the V/C ratios drop by about 22 % (from 0.90 to 0.70), however, there is no change in the operating speeds on the general purpose lanes. This is because the V/C ratios and operating speeds from the 8 Lane alternative under the "No Toll" conditions shows peak period congestion levels much lower than that compared to the 4 and 6 Lane alternatives. In other words, the greater the congestion is during peak periods (high V/C ratios and low speeds) under "No Toll" conditions, the larger the resulting change in V/C ratios and operating speeds from the introduction of tolls.

On the other hand, operating conditions on HOV lanes in the Trans-Lake corridor lanes do not deteriorate when either the 4, 6 or 8 lane alternatives are tolled. V/C ratios on HOV lanes are below 0.80 with operating speeds of 55 mph to 60 mph.

Observations – Toll on SR 520 and I-90

Changes to V/C ratios and operating speeds on the Lake Washington bridge when both SR 520 and I-90 are tolled is presented in Figures 11, 14, and 17.

As shown in Figures 9 and 11, toll on SR 520 and I-90 under the 4 Lane alternative results in a 15% reduction in V/C ratios during the peak periods (from 1.40 to 1.20), with no change in operating speeds on SR 520. A similar reduction of about 17% in V/C ratios (from 1.15 to 0.95) is observed during the off-peak period, with operating speeds on SR 520 improving from 10 mph to 55 mph.

Figures 12 and 14, show changes in V/C ratios and operating speeds from the 6 Lane alternative. Tolls on SR 520 and I-90 result in a 15% reduction in V/C ratios during the peak periods, with operating speeds on the general purpose lanes improving from below 10 mph to about 20 mph. During the off-peak period the V/C ratios improve by about 18% (from 1.15 to 0.95), and operating speeds on the general purpose lanes improve from 20 mph to 55 mph.

Figures 15 and 17, show changes in V/C ratios and operating speeds from the 8 Lane alternative. Tolls on SR 520 and I-90 result in a 15% reduction in V/C ratios during the peak periods (from 1.0 to 0.85), with operating speeds on the general purpose lanes improving from about 45 mph to 60 mph. During the of-peak period the V/C ratios drop by 17% (from 0.90 to 0.75), however, there is no change in the operating speeds on the general purpose lanes. They continue to operate at free-flow conditions of 60 mph. Once again, because of the low levels of congestion observed during the peak and off-peak period from the 8 Lane alternative with no tolls, the response to tolls from this alternative is not as much as that reflected in the 4 and 6 Lane alternatives.

As with the case of tolling SR 520 only, operating conditions on HOV lanes in the Trans-Lake corridor lanes do not deteriorate when either the 4, 6 or 8 lane alternatives are tolled. V/C ratios on HOV lanes are below 0.80 with operating speeds of 55 mph to 60 mph.

Summary

Value pricing has an impact on the V/C ratios and operating speeds on SR 520. Tolls on SR 520 and I-90 will provide a 15% to 24% improvement in V/C ratios accompanied by improved operating speeds on the general purpose lanes. On the other hand, In general, the improvement to V/C ratios and operating speeds on the SR 520 corridor varies with the level of congestion experienced. In other words, the greater the congestion is during peak periods (high V/C ratios and low speeds) under "No Toll" conditions, the larger the resulting change in V/C ratios and operating speeds from the introduction of tolls.

Figure 9
Year 2030 Mid-Lake SR-520 V/C Ratio and Speed
4-Lane Alternative - No Toll

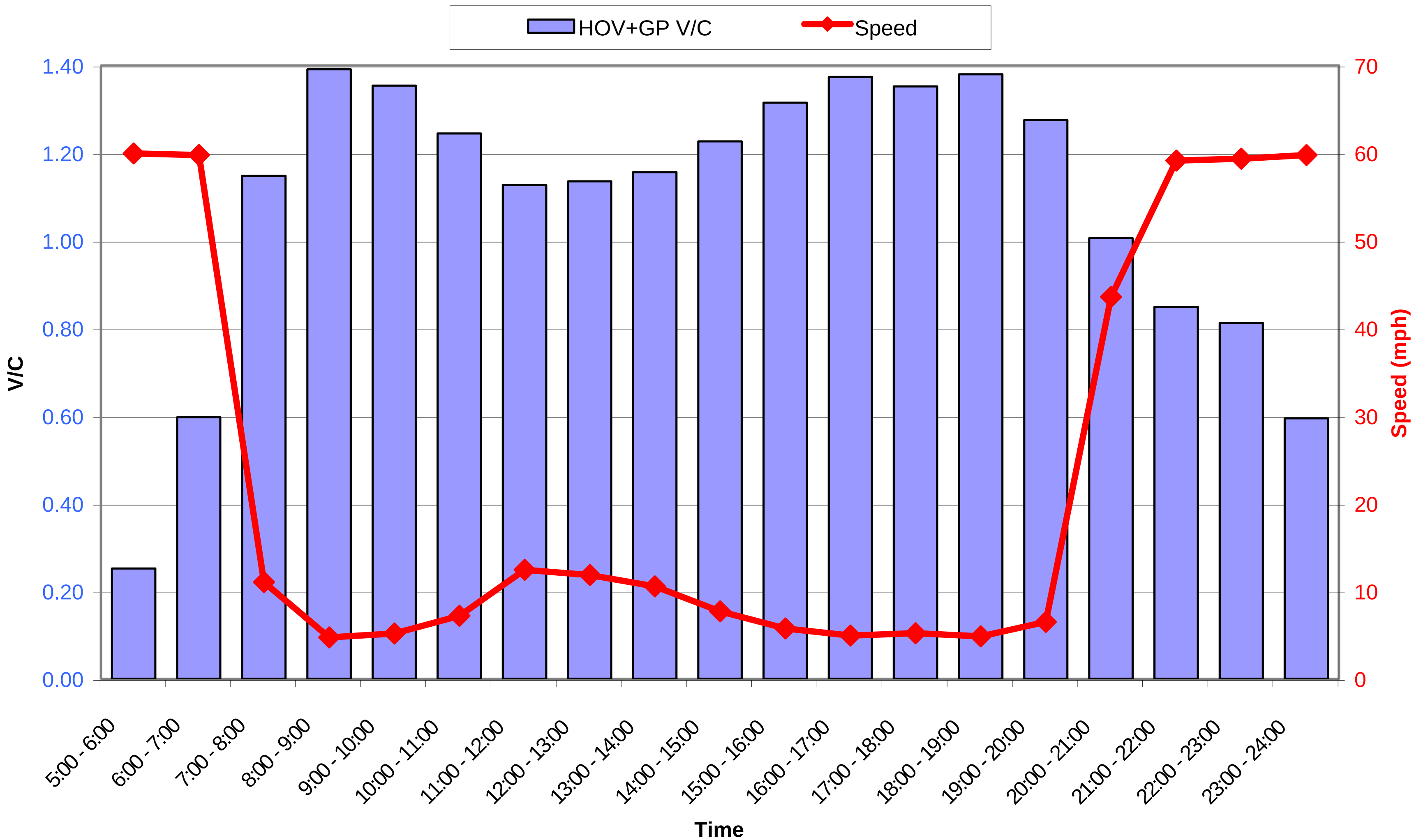


Figure 10
Year 2030 Mid-Lake SR-520 V/C Ratio and Speed
4-Lane Alternative - Toll on SR-520

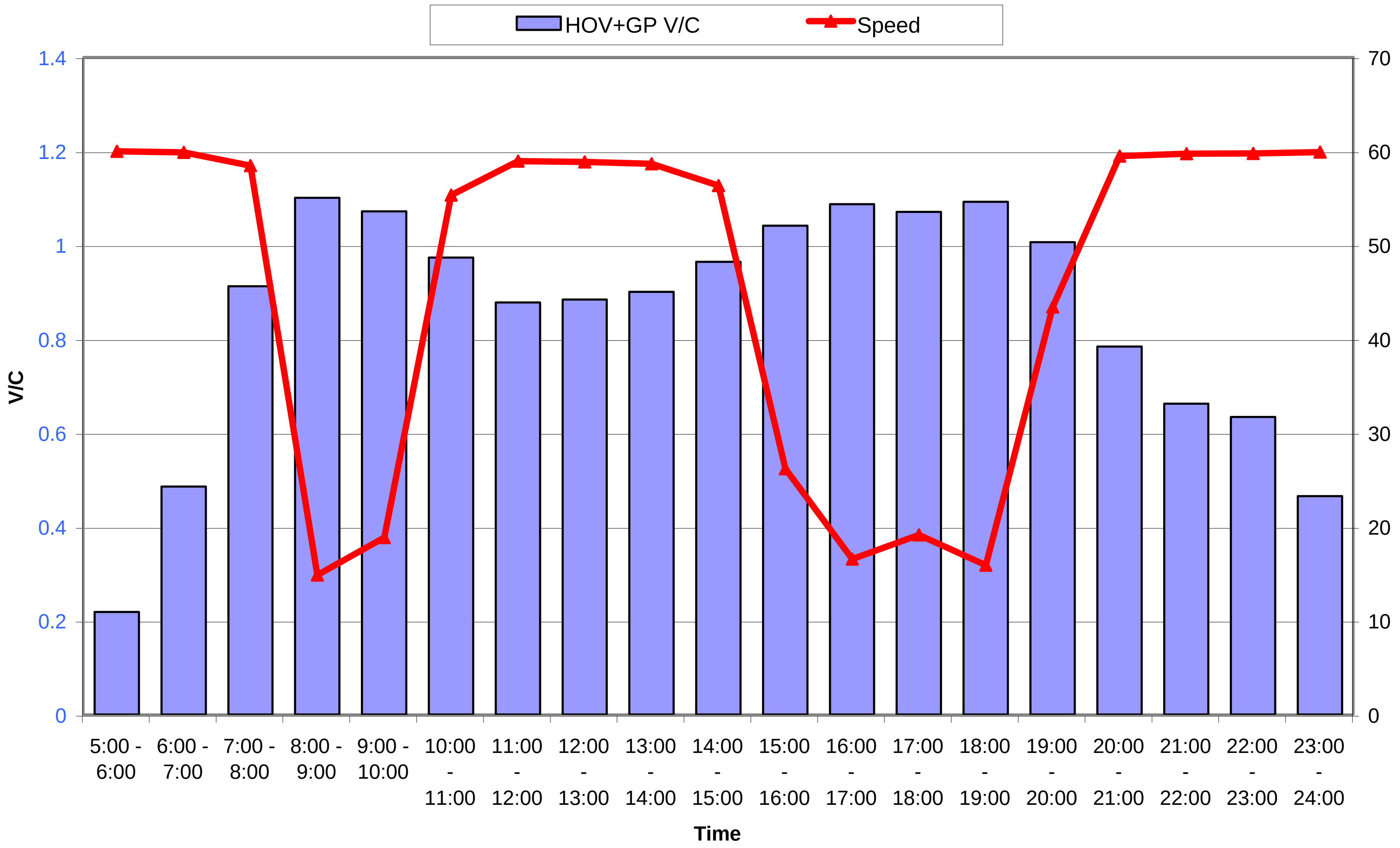
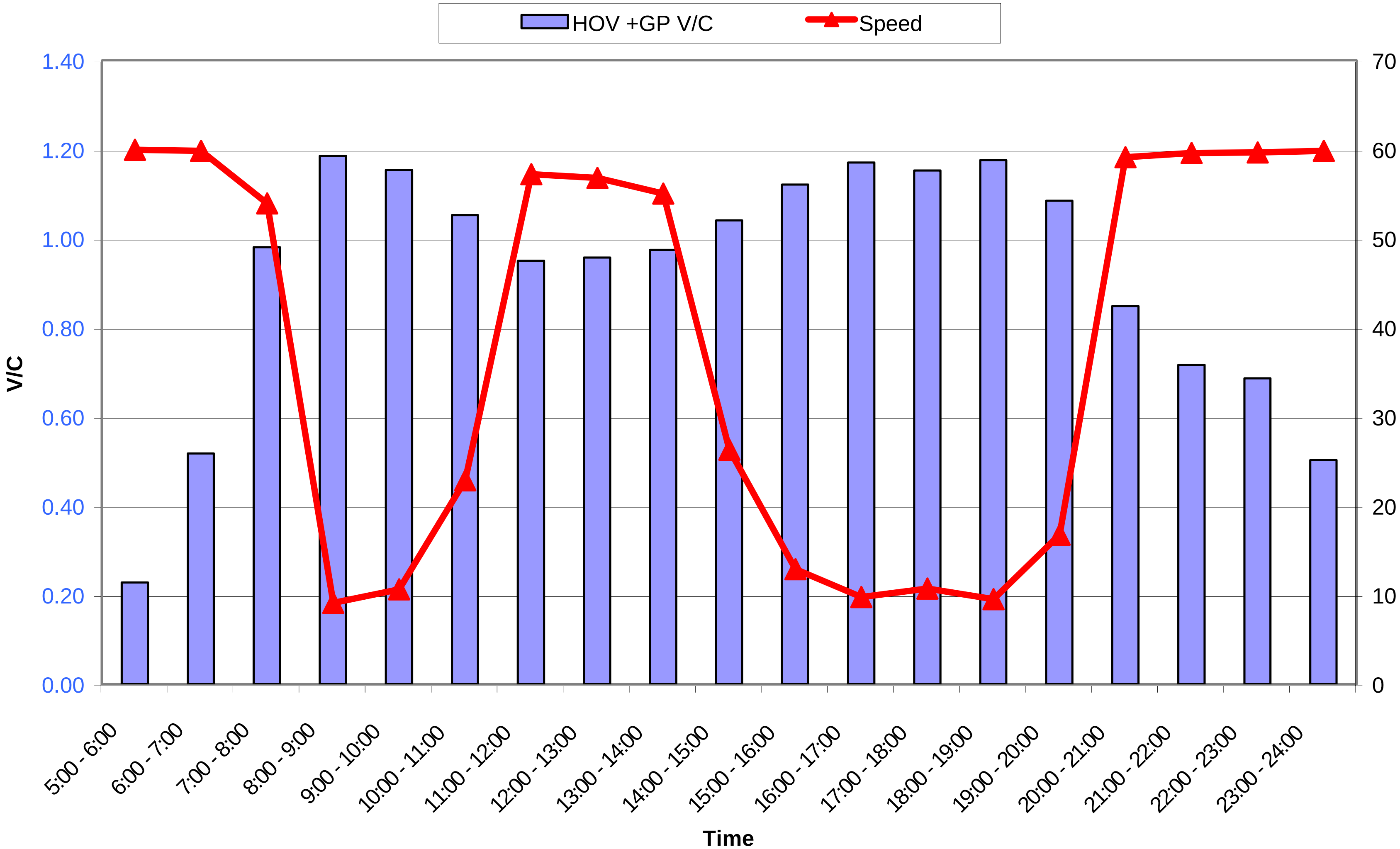


Figure 11
Year 2030 Mid-Lake SR-520 V/C Ratio and Speed
4-Lane Alternative - Toll on SR-520 & I-90



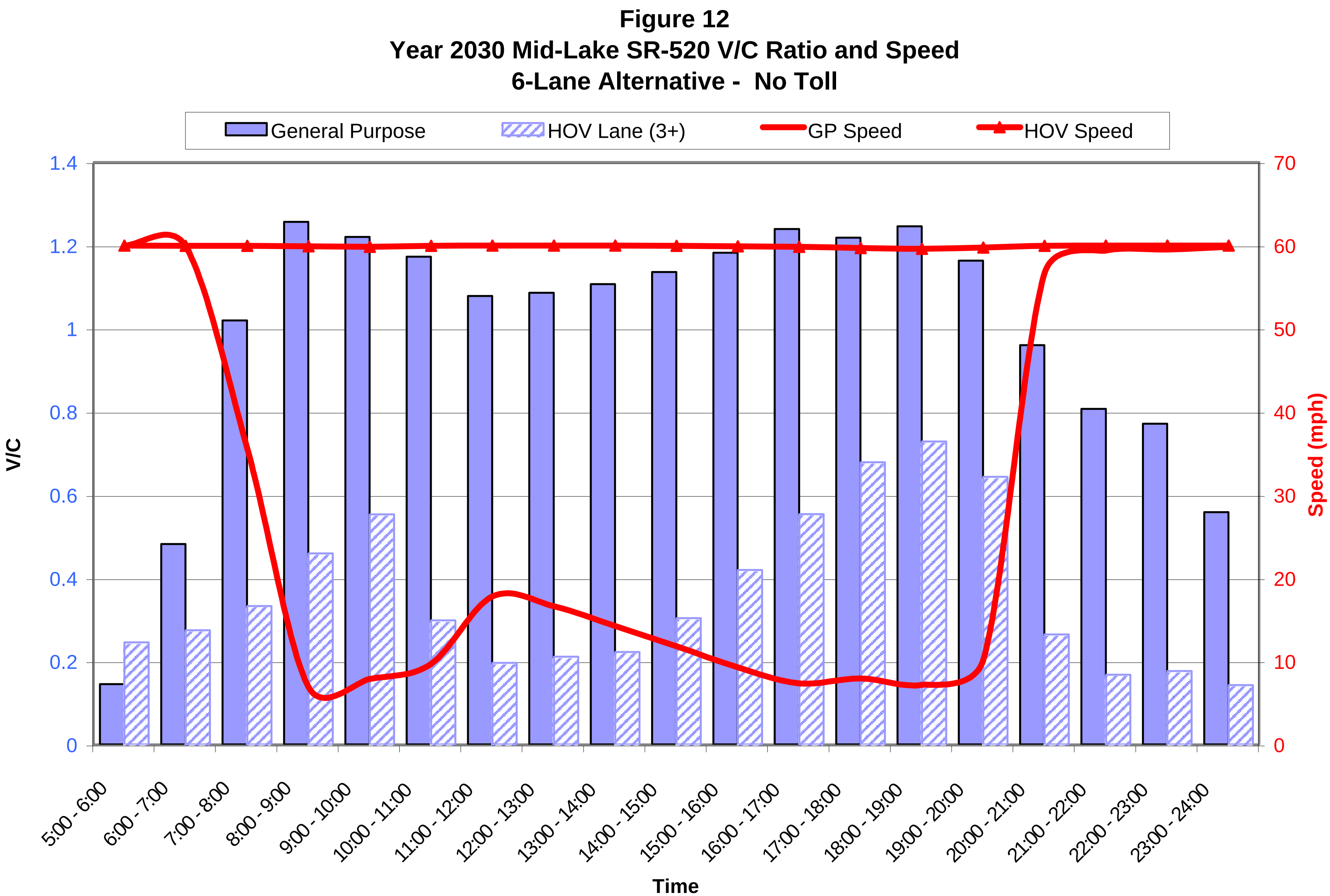


Figure 12
Year 2030 Mid-Lake SR-520 V/C Ratio and Speed
6-Lane Alternative - No Toll
General Purpose
HOV Lane (3+)
GP Speed
HOV Speed
V/C
Speed (mph)
Time
0
0.2
0.4
0.6
0.8
1
1.2
1.4
0
10
20
30
40
50
60
70
5:00 - 6:00
6:00 - 7:00
7:00 - 8:00
8:00 - 9:00
9:00 - 10:00
10:00 - 11:00
11:00 - 12:00
12:00 - 13:00
13:00 - 14:00
14:00 - 15:00
15:00 - 16:00
16:00 - 17:00
17:00 - 18:00
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21:00 - 22:00
22:00 - 23:00
23:00 - 24:00

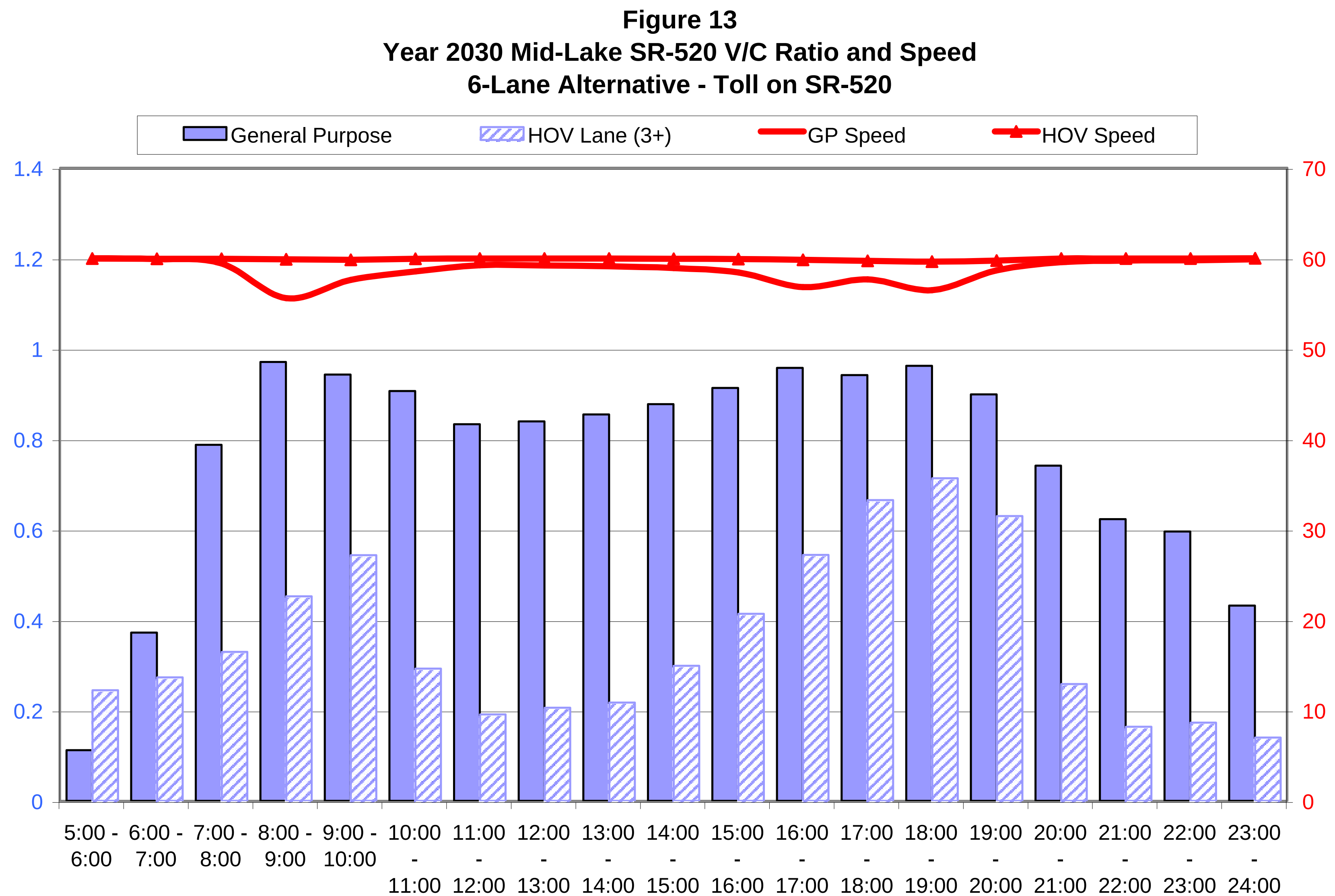


Figure 13
Year 2030 Mid-Lake SR-520 V/C Ratio and Speed
6-Lane Alternative - Toll on SR-520
General Purpose
HOV Lane (3+)
GP Speed
HOV Speed
1.4
1.2
1
0.8
0.6
0.4
0.2
0
70
60
50
40
30
20
10
0
5:00 - 6:00
6:00 - 7:00
7:00 - 8:00
8:00 - 9:00
9:00 - 10:00
10:00 - 11:00
11:00 - 12:00
12:00 - 13:00
13:00 - 14:00
14:00 - 15:00
15:00 - 16:00
16:00 - 17:00
17:00 - 18:00
18:00 - 19:00
19:00 - 20:00
20:00 - 21:00
21:00 - 22:00
22:00 - 23:00
23:00 - 24:00

Figure 14
Year 2030 Mid-Lake SR-520 Volume to Capacity Ratio
6-Lane Alternative - Toll on SR-520 & I-90

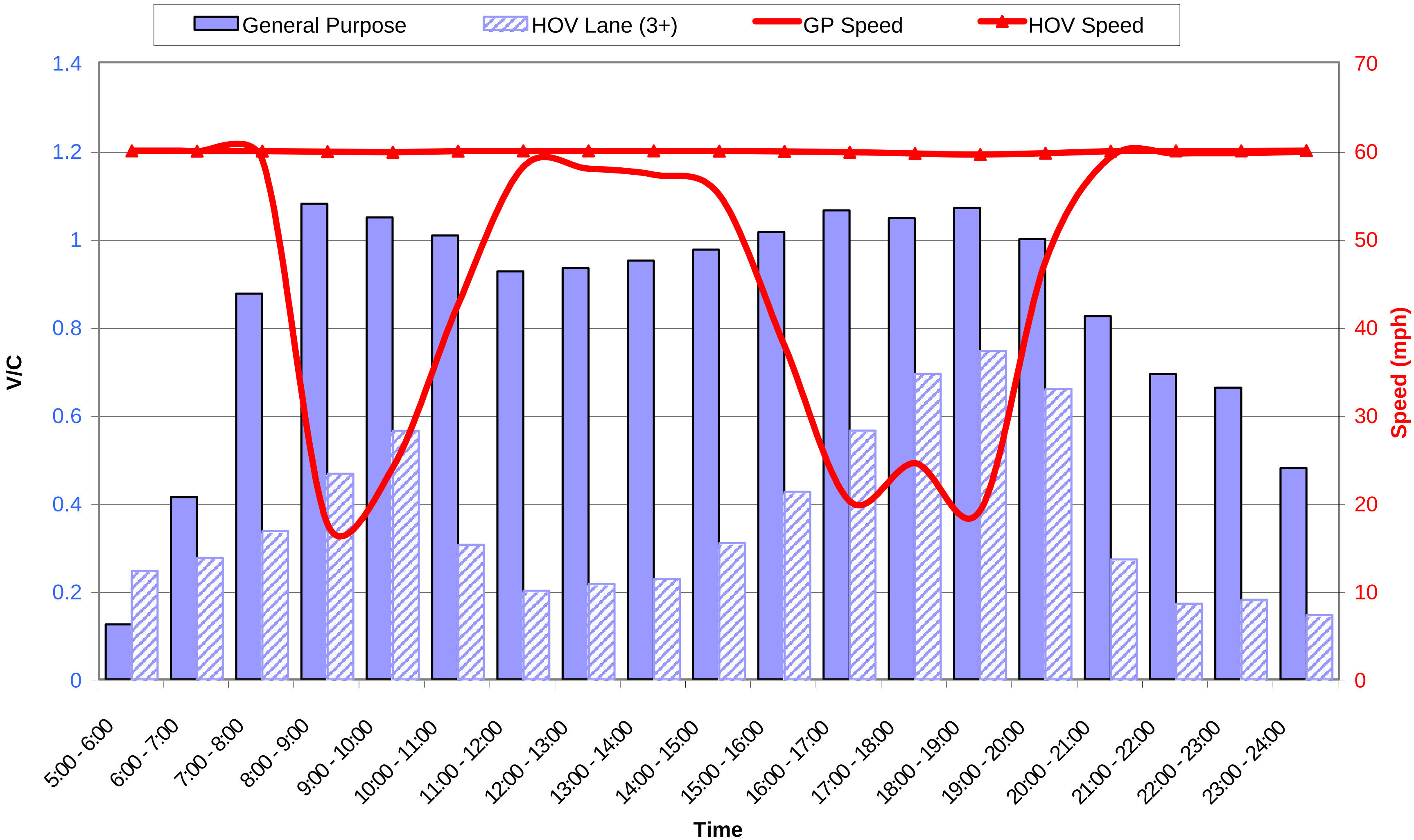


Figure 15
Year 2030 Mid-Lake SR-520 V/C Ratio and Speed
8-Lane Alternative - No Toll

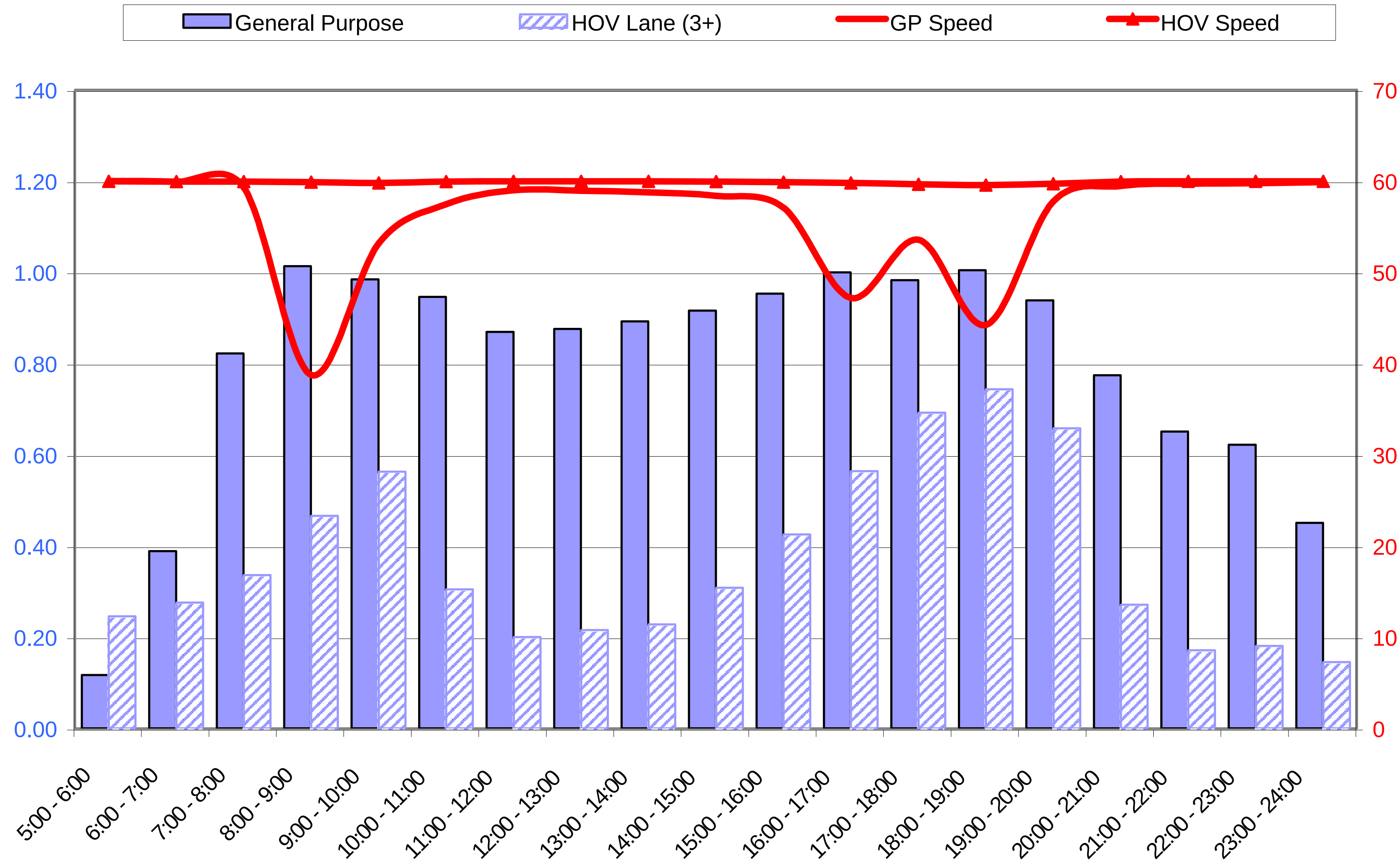


Figure 16
Year 2030 Mid-Lake SR-520 V/C Ratio and Speed
8-Lane Alternative - Toll on SR-520

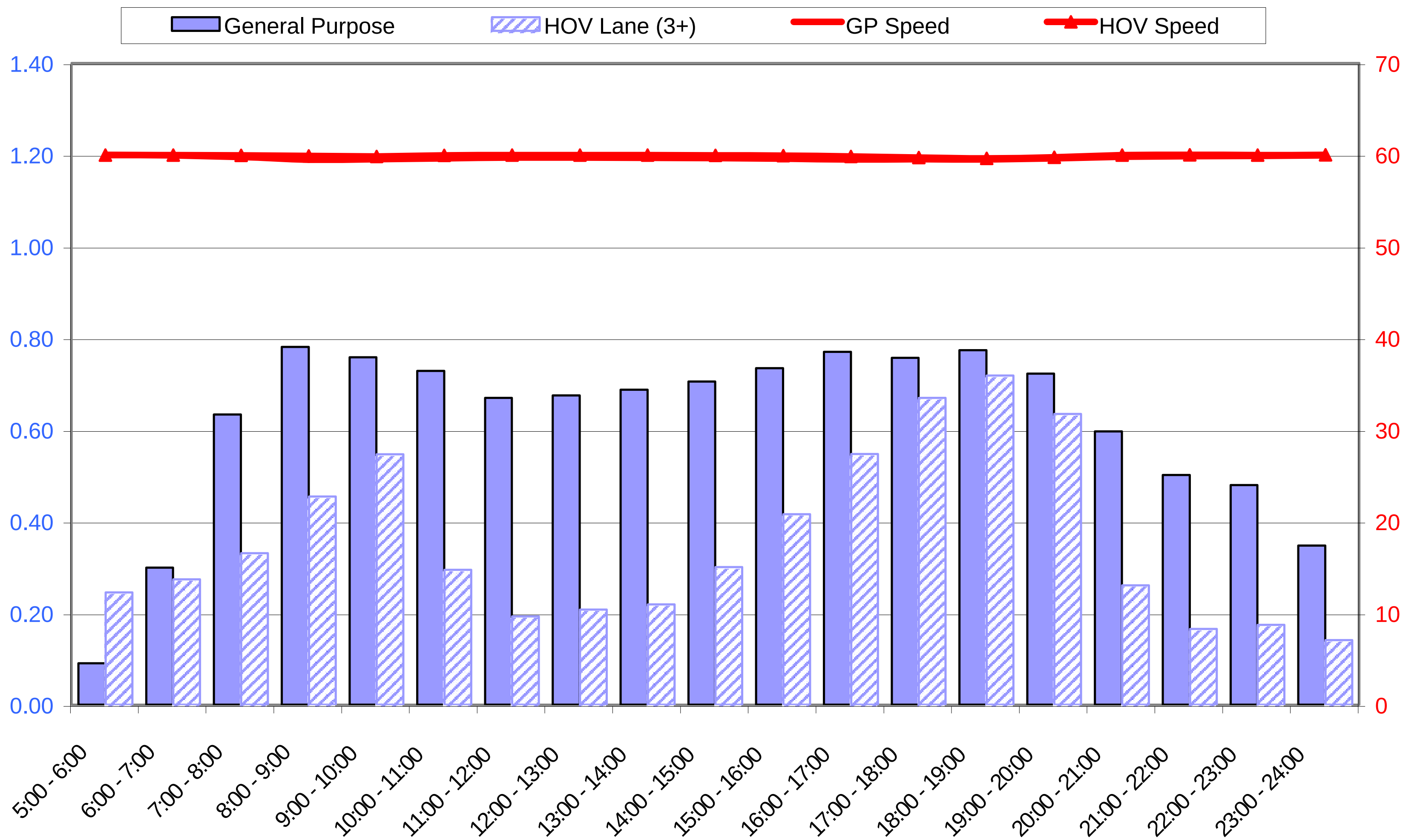
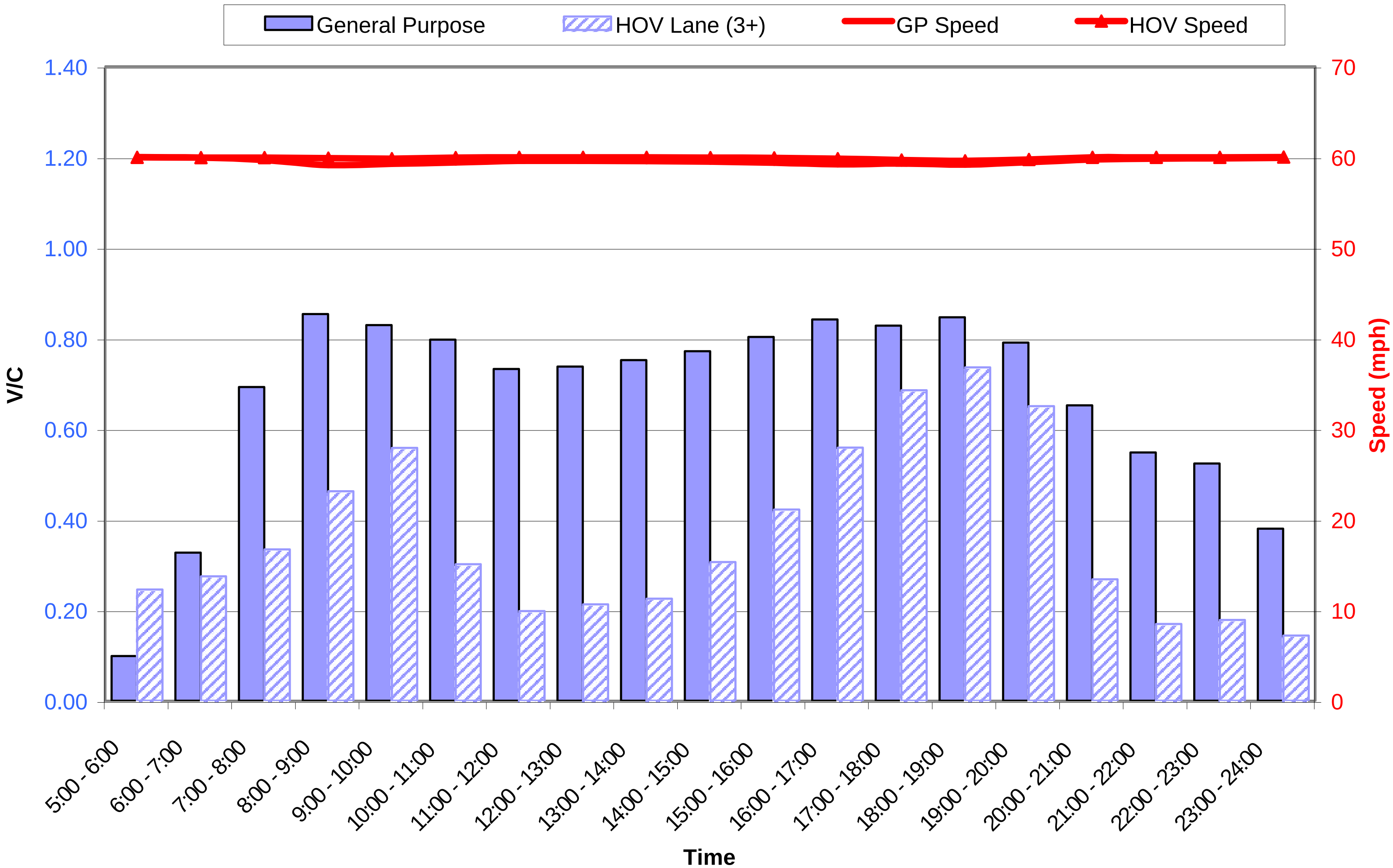


Figure 17
Year 2030 Mid-Lake SR-520 V/C Ratio and Speed
8-Lane Alternative - Toll on SR-520 & I-90



Mode Share

The mode share analysis focuses on the percentage of trips made by HOV, Non-HOV, and Transit modes for each of the 4, 6, and 8 Lane alternatives. This information is derived from the PSRC model person trip forecasts, and is provided in detail in the Appendix to this memorandum. Table 4 provides a summary of the modal shifts resulting from the application of tolls to cross-Lake Washington trips.

Table 4: 1998 and 2030 Daily Mode Shares on SR 520 With and Without Toll

Alternative	HOV Trips	Transit Trips	Non-HOV Trips
Existing (1998)	2.0 percent	6.0 percent	92.0 percent
4 Lane Alternative (2030):			
– No Toll	10.9 percent	15.5 percent	73.6 percent
– Toll on SR 520	11.7 percent	21.1 percent	67.2 percent
– Toll on SR 520 & I-90	9.3 percent	20.2 percent	70.5 percent
6 Lane Alternative (2030):			
– No Toll	14.2 percent	18.5 percent	67.3 percent
– Toll on SR 520	18.3 percent	24.0 percent	57.7 percent
– Toll on SR 520 & I-90	17.2 percent	22.2 percent	60.6 percent
8 Lane Alternative (2030):			
– No Toll	12.2 percent	16.3 percent	71.5 percent
– Toll on SR 520	16.3 percent	20.7 percent	63.0 percent
– Toll on SR 520 & I-90	15.1 percent	19.4 percent	65.5 percent

Observations – Toll on SR 520 Only

With tolls on SR 520, HOV trips increase by 1% to 4%, and transit trips increase by 4% to 6%, compared to 2030 conditions without tolls. As shown in Table 4, the highest mode shift of almost 10% (4% HOV and 5.5% Transit) occurs with the 6 Lane alternative, while the 8 Lane and 4 Lane alternatives show modal shifts of 8.50% and 6% respectively.

Observations – Toll on SR 520 and I-90

When both SR 520 and I-90 are tolled, the response to modal shifts is lower than that resulting from when only SR 520 is tolled. As shown in Table 4, the 6 Lane alternative still has the highest mode shift of about 6.50% (3% HOV and 3.5% Transit), while the 8 Lane and 4 Lane alternatives show modal shifts of 6% and 3% respectively, compared to 2030 conditions without tolls.

Summary

The introduction of value pricing on SR 520 and I-90 result in increases in HOV and transit trips crossing Lake Washington. The largest mode shift of 6% to 10% from non-HOV modes to HOV and transit modes is observed under the 6 Lane alternative, while the 8 and 4 Lane alternatives show mode shifts ranging between 8.5% and 3.0%, compared to 2030 conditions without tolls.

Evaluation of the Managed Lanes Alternative

The following discussion presents the results from modeling the 8 Lane - Managed Lanes alternative. The performance of the Managed Lane alternative in comparison to the 8 Lane Base alternative (without toll) is presented below. This includes an analysis of the travel demand and traffic operations, i.e., V/C ratios and speeds on the SR 520 corridor.

The 8 Lane – Managed Lanes alternative as illustrated in Figure 18, consists of 4 general purpose lanes and 4 HOV lanes along the SR 520 corridor. The management component of this alternative relates primarily to managing access to the HOV lanes. This alternative provides free access to all HOV 3+ and transit users along the corridor, as well as, limited access to HOV 2 users. HOV 2 users will pay a toll to access the managed lanes at the following locations:

- Montlake Blvd.
- Bellevue Way/104th Avenue NE (direct HOV access ramps)
- I-405 (via freeway-to-freeway HOV ramps)
- Vicinity of NE 32nd Street (direct HOV access ramps near Overlake)
- SR 202 (east terminus)

These access points to the managed lanes were selected primarily because they serve as gateways to key activity centers (University of Washington and Bel-Red Overlake area), as well as direct access points for transit to access and egress the corridor. In addition, an HOV slip ramp to/from the mainline was assumed between 84th Avenue NE and 92 Avenue NE.

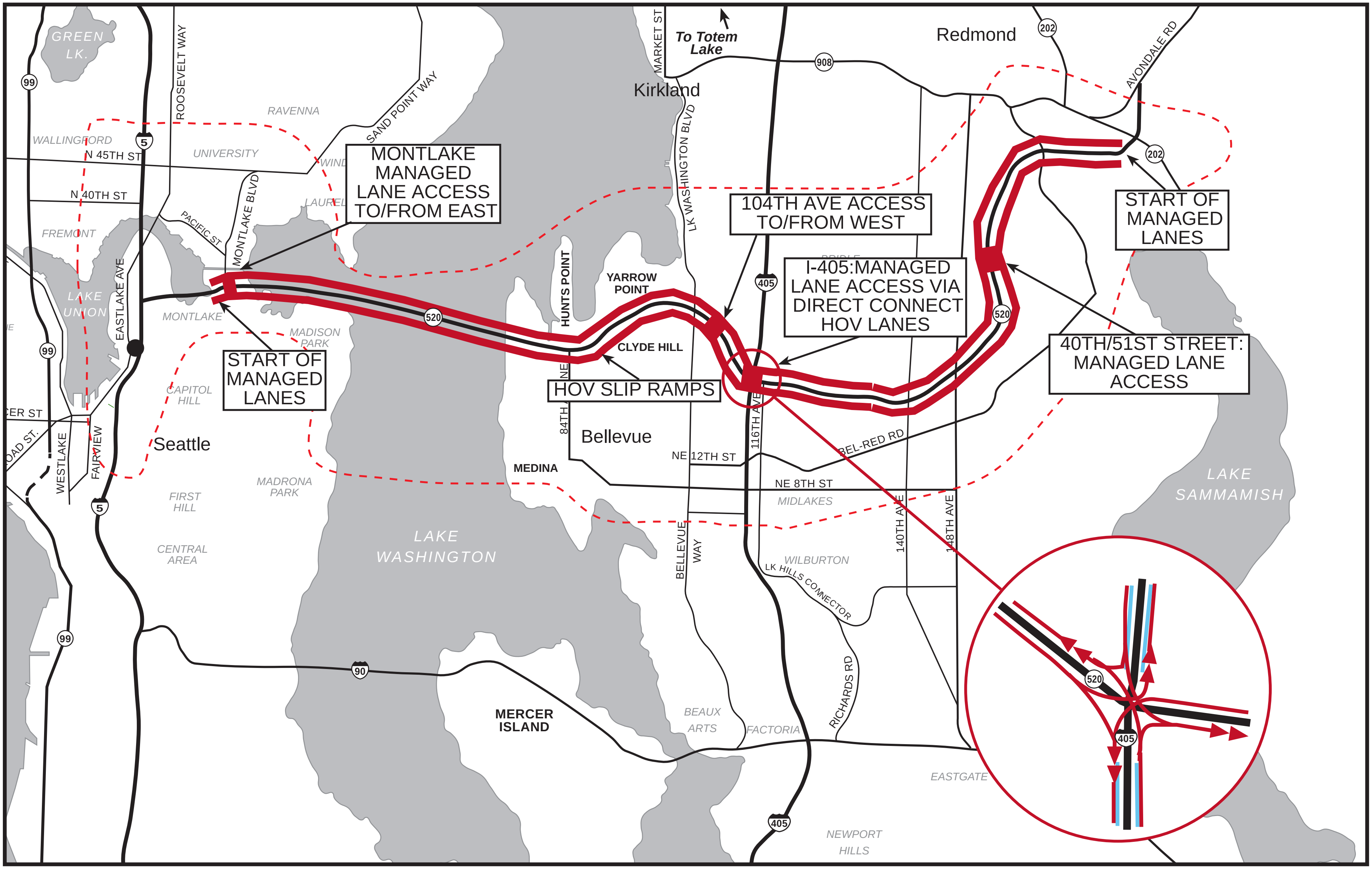
The extent of the analysis is limited to the evaluation of cross-Lake Washington traffic patterns on SR 520 across the following four screenline locations:

- Lake Washington Bridge
- East of Bellevue Way NE and West of I-405
- East of I-405 and West of 124th Avenue NE
- North of NE 51st Street and West of W. Lake Sammamish Parkway

Travel Demand

The vehicle travel demand at four locations along the SR 520 corridor is shown in Table 5. The table compares the AM and PM peak periods, off-peak period, and daily vehicle trips across four screenlines from the Managed Lane alternative against the 8 Lane Base alternative. A general observation is that while vehicle throughput in the managed HOV lanes increased across all four screenlines, the demand on the mainline decreased. This is primarily due to the conversion of 2 general purpose lanes from the 8 Lane Base alternative to HOV and transit only lanes in the 8 Lane - Managed Lanes alternative.

HOV travel demand showed significant increases across all the screenlines, with the highest increases of nearly 300% being recorded on the 2 screenlines west of I-405, and the screenline at NE 51st Street (Redmond). Non-HOV travel demand showed significant decreases of nearly 20% across the 2 screenlines west of I-405, and about 10% across the NE 51st Street screenline.



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Study Area Boundary
Access Locations
Managed Lanes
HOV Lanes
GP Lanes

Figure 18
Managed Lanes Access Points

Table 5: Vehicle Travel Demand – Managed Lane Alternative

on SR 520 Lake Washington Bridge

	SR 520 - 8 Lane Alternative (with Managed Lanes)			SR 520 - 8 Lane Alternative (without Managed Lanes)			Change in Total Volume	Percent Change from PA
	Mainline	Managed Lanes	Total	GP Lane	HOV (3+) Lane	Total		
AM Peak (3 hours)	27,400	11,500	38,900	35,200	4,200	39,400	(500)	-1%
PM Peak (3 hours)	34,600	10,300	44,900	45,100	3,400	48,500	(3,600)	-7%
Off Peak (18 hours)	85,700	15,400	101,100	106,300	5,100	111,400	(10,300)	-9%
Total Daily (24 hours)	147,700	37,200	184,900	186,600	12,700	199,300	(14,400)	-7%

on SR 520 East of Bellevue Way NE and West of I-405 (Kirkland)

	SR 520 - 8 Lane Alternative (with Managed Lanes)			SR 520 - 8 Lane Alternative (without Managed Lanes)			Change in Total Volume	Percent Change from PA
	Mainline	Managed Lanes	Total	GP Lane	HOV (3+) Lane	Total		
AM Peak (3 hours)	23,000	8,500	31,500	27,900	3,000	30,900	600	2%
PM Peak (3 hours)	28,800	8,300	37,100	37,200	2,800	40,000	(2,900)	-7%
Off Peak (18 hours)	70,200	12,200	82,400	86,900	4,200	91,100	(8,700)	-10%
Total Daily (24 hours)	122,000	29,000	151,000	152,000	10,000	162,000	(11,000)	-7%

on SR 520 East of I-405 and West of 124th NE (Bellevue)

	SR 520 - 8 Lane Alternative (with Managed Lanes)			SR 520 - 8 Lane Alternative (without Managed Lanes)			Change in Total Volume	Percent Change from PA
	Mainline	Managed Lanes	Total	GP Lane	HOV (3+) Lane	Total		
AM Peak (3 hours)	20,700	4,700	25,400	22,200	3,200	25,400	-	0%
PM Peak (3 hours)	26,800	3,800	30,600	31,000	2,600	33,600	(3,000)	-9%
Off Peak (18 hours)	62,800	5,900	68,700	72,300	4,200	76,500	(7,800)	-10%
Total Daily (24 hours)	110,300	14,400	124,700	125,500	10,000	135,500	(10,800)	-8%

On SR 520 North of NE 51st and West of W Lake Sammamish (Redmond)

	SR 520 - 8 Lane Alternative (with Managed Lanes)			SR 520 - 8 Lane Alternative (without Managed Lanes)			Change in Total Volume	Percent Change from PA
	Mainline	Managed Lanes	Total	GP Lane	HOV (3+) Lane	Total		
AM Peak (3 hours)	29,700	4,100	33,800	32,900	1,600	34,500	(700)	-2%
PM Peak (3 hours)	38,500	3,800	42,300	43,600	1,200	44,800	(2,500)	-6%
Off Peak (18 hours)	99,000	5,300	104,300	107,500	2,000	109,500	(5,200)	-5%
Total Daily (24 hours)	167,200	13,200	180,400	184,000	4,800	188,800	(8,400)	-4%

The total travel demand across all four screenlines as shown in Table 6 for the AM, PM and off-peak periods, also shows a general decrease of about 4% to 8% in total trip activity on the SR 520 corridor. This primarily reflects the reduction in the overall demand for non-HOV trips along the corridor due to the decrease in general purpose capacity caused by the conversion of 2 general purpose lanes to 2 Managed lanes.

Table 6: Comparison of 2030 Daily Vehicle Trips

Screenline	8 Lane Base Alternative	8 Lane - Managed Lane Alternative	Difference
Lake Washington Bridge	199,300	184,900	- 14,400
East of Bellevue Way NE and West of I-405	162,000	151,000	- 11,000
East of I-405 and West of 124th Avenue NE	135,500	124,700	- 10,800
North of NE 51st and West of W. Lake Sammamish Pkwy.	188,800	180,400	- 8,400

Volume to Capacity (V/C) Ratios and Speeds

Figures 19 and 20 show the operating conditions on the SR 520 bridge for the 8 Lane Base alternative and the 8 Lane - Managed Lanes alternatives respectively.

Calculation of V/C Ratios and Speeds

The V/C ratios and speeds for the SR 520 bridge under the 8 Lane – Managed Lanes alternative was calculated based on the following assumptions:

- 2030 daily traffic forecasts from the 8 Lane – Base Alternative and the 8 Lane – Managed Lanes alternatives served as the starting point for this analysis.
- Existing daily traffic volume distribution on SR 520 (near 76th Street) was used to generate the future hourly traffic volume distribution for the general purpose lanes and the HOV lanes.
- The 8 Lane alternative assumes a lane capacity of 2200 vehicles per hour per lane. The higher capacity per lane was assumed to take into account the two additional lanes that are being considered on the SR 520 bridge, in addition to the standard improvements to shoulder width, lane width, and improved sight distance.
- A HOV lane capacity of 1800 vehicles per hour.
- Buses were converted to PCE and added to the HOV lane volumes.
- A PCE conversion factor of 3.1 was used. This assumes 50 percent of the buses to be articulated

with a PCE of 4 and the remainder to be single unit buses with a PCE factor of 2.2.

- 2030 general purpose traffic volumes were converted to PCEs assuming 5% heavy vehicles with a PCE factor of 2.2.

The 8 Lane - Base alternative (Figure 19) shows the general purpose lanes during peak periods to be operating at a V/C ratio of 1.0 with operating speeds ranging between 40 mph and 50. While, the HOV lanes operate at V/C ratios ranging between 0.40 and 0.75 and an average speed of 60 mph.

With the conversion of 2 general purpose lanes to 2 HOV lanes in the Managed Lanes alternative, the travel conditions during the peak periods on the general purpose lanes deteriorate to V/C ratios of 1.00 to 1.10, with speeds dropping down to the 20mph – 25mph range. The HOV lanes still continue to operate under uncongested conditions – V/C ratios of 0.40 to 0.80 and an average speed of 60 mph (Figure 20).

Summary

The demand for non-HOV trips on the Trans-Lake corridor is considerably higher than for HOV trips. The provision of additional HOV capacity on the corridor with limited access points to HOV 2 users does create a large shift of non-HOV trips to HOV trips. However, our analysis shows a significant amount of capacity to be still available in the Managed Lanes. Providing full access to HOV 2 users beyond just those allowed in the Managed Lanes alternative could lead to additional HOV 2 trips diverting from the general purpose lanes to the HOV lanes. This could result in improving operating conditions on the general purpose lanes, while providing for a more balanced flow of non-HOV and HOV trips along the corridor. Another possibility for using the excess capacity on the managed lanes, as well as balance HOV and non-HOV flows would be to allow SOV to pay a fee for using the uncongested managed lanes.

Figure 19
Year 2030 Mid-Lake SR-520 V/C Ratio and Speed
8-Lane Alternative - No Toll

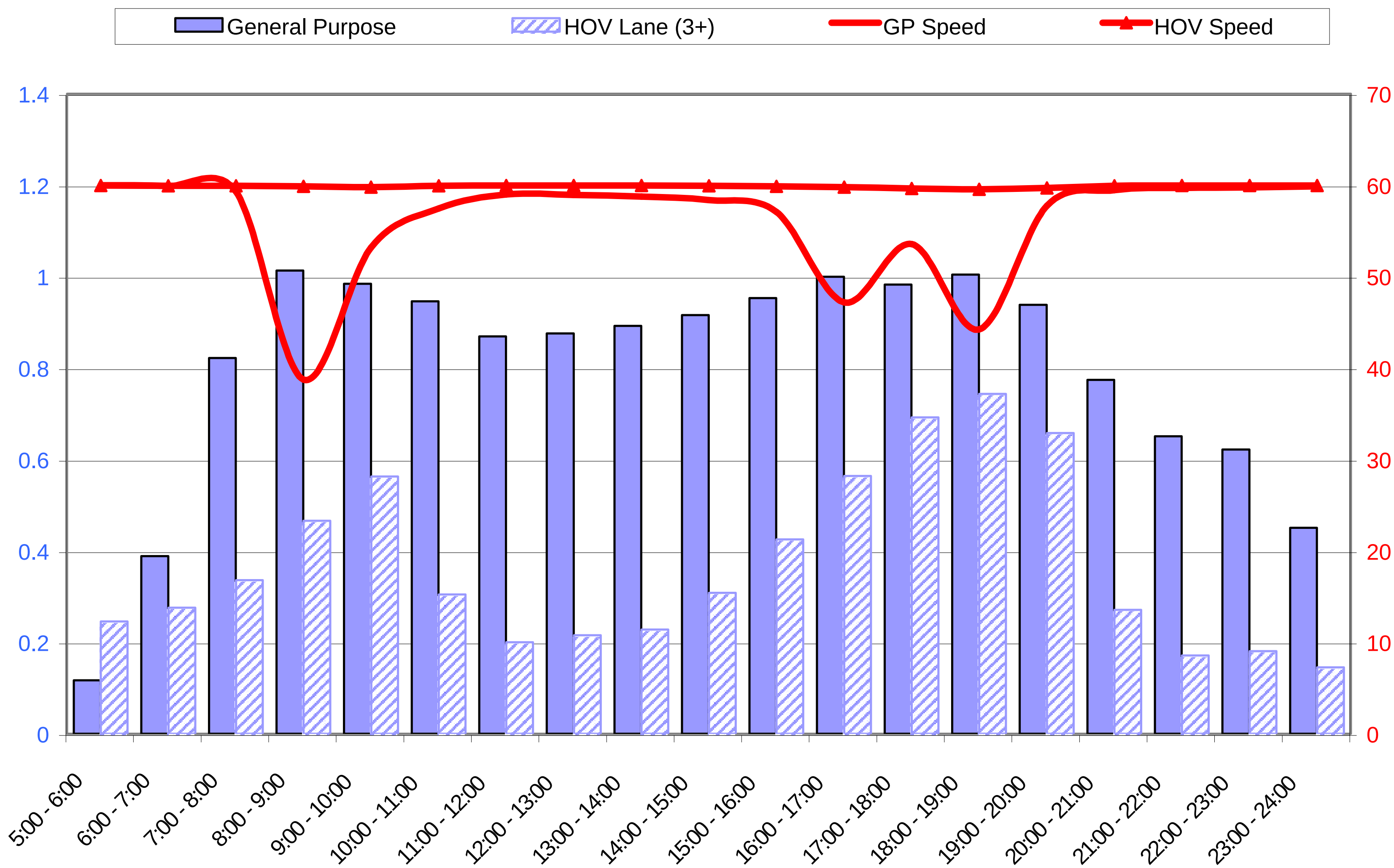
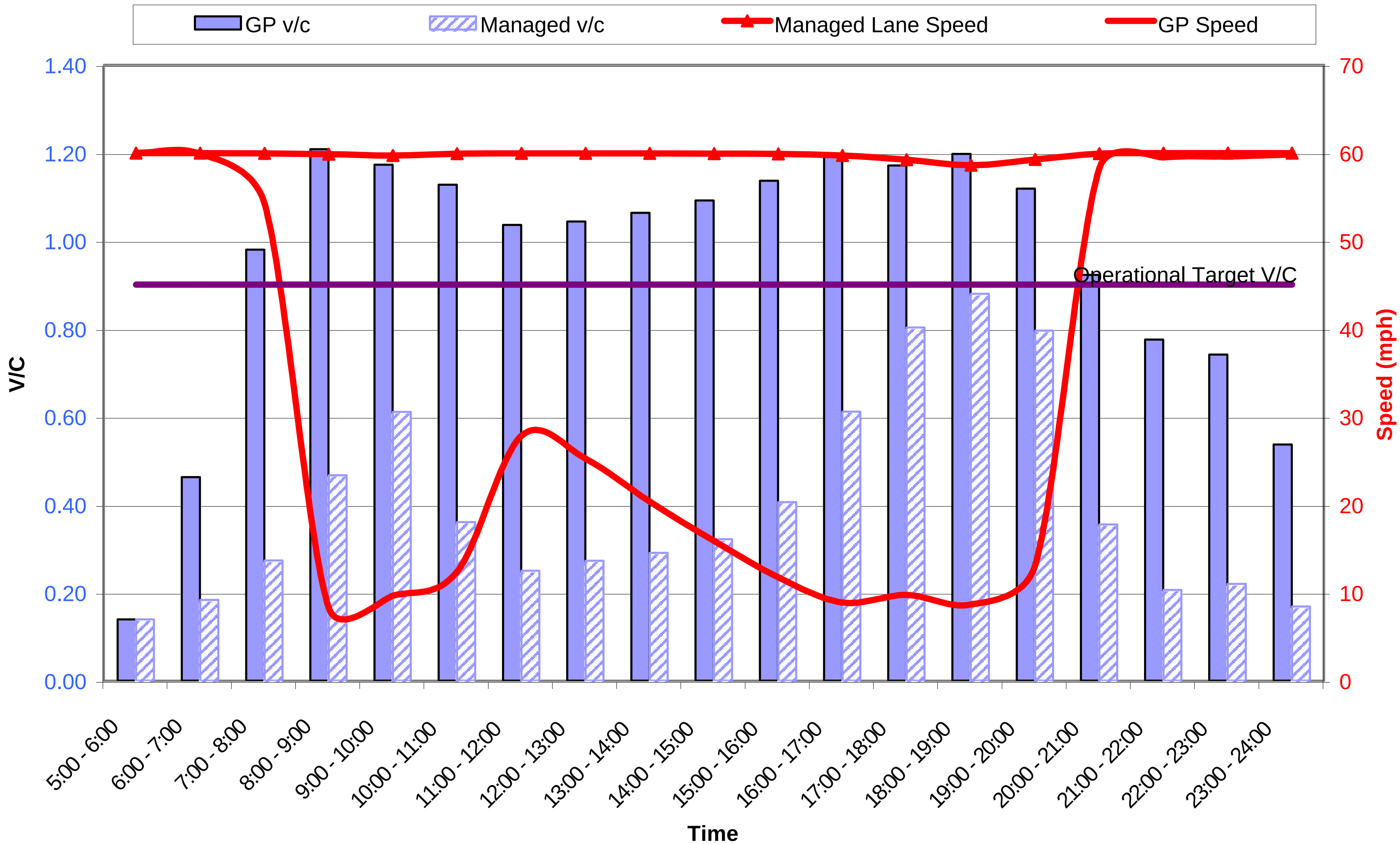


Figure 20
Year 2030 Mid-Lake SR-520 V/C Ratio and Speed
8-Lane Alternative - Managed Lanes



SUMMARY OF FINDINGS – TRANS-LAKE PRICING ANALYSIS

Pricing Assumptions - Base Value of Time:

- Average peak period toll for one-way trip on the full length of SR 520 in 2014: $1.15 to $1.80
- Average peak period toll for one-way trip on the full length of SR 520 in 2030: $1.41 to $2.43
- Average peak period toll for one-way trip on the full length of I-90 in 2014: $0.80 to $1.20
- Average peak period toll for one-way trip on the full length of I-90 in 2030: $0.93 to $1.73

Pricing Assumptions - Low Value of Time:

- Average peak period toll for one-way trip on the full length of SR 520 in 2014: $0.77 to $1.15
- Average peak period toll for one-way trip on the full length of SR 520 in 2030: $0.90 to $1.54
- Average peak period toll for one-way trip on the full length of I-90 in 2014: $0.53 to $0.80
- Average peak period toll for one-way trip on the full length of I-90 in 2030: $0.67 to $1.20

Findings from Value Pricing on SR 520:

The following summary observations can be made based upon the modeling and traffic analyses conducted in this study:

- Value pricing has an overall impact on the travel demand, travel patterns, and traffic operations in the Trans-Lake corridor.
- The travel demand analyses show decreases in person and vehicle throughput when pricing is introduced to the Trans-Lake corridor. The decreases in person throughput are in the range of 10 to 15 percent, while reductions in vehicle throughput are around 20 percent.
- The traffic analysis shows improvements to operating conditions on the Lake Washington bridge. On average, the V/C ratios on the general purpose lanes along the corridor improve by 25 percent, accompanied by increases in operating speeds to reflect uncongested flows on the general purpose lanes on SR 520, while HOV lanes continue to operate at uncongested speeds.
- The mode share analyses show HOV and transit trips to increase by 6 to 10 percent when pricing is introduced to the corridor.
- An analysis of the travel patterns shows diversion of traffic resulting from peak period value pricing. The reductions in vehicular traffic on SR 520, results in diversion of traffic to the I-90 and SR 522 corridors, and on to local eastside arterials:
    - 20 percent decrease in traffic on SR 520
    - 8 to 11 percent increases in traffic on I-90
    - 4 to 6 percent increase in traffic on SR 522
    - 3 to 5 percent increase in traffic on arterial roadways in the communities of Seattle, Bellevue, Kirkland, Redmond, and the Points Communities.

Findings from Value Pricing on SR 520 and I-90:

While, most of the trends are similar to that observed from value pricing on SR 520 only, the changes in travel patterns and traffic diversion impacts are of a lower order.

- Pricing does impact the travel demand, travel patterns, and traffic operations in the Trans-Lake corridors.
- The travel demand analyses show decreases in person and vehicle throughput when pricing is introduced to the Trans-Lake corridors. While the decreases in person throughput are in the range of 5 to 11 percent, reductions in vehicle throughput range from 12 to 15 percent.
- While, the traffic analysis shows improvements to operating conditions on SR 520 and I-90, SR 522 shows a degradation in operating conditions. On average, the V/C ratios on the general purpose lanes (on SR 520 and I-90) along the corridor improve by 20 percent, accompanied by increases in operating speeds on the general purpose lanes. HOV lanes continue to operate at uncongested speeds on both SR 520 and I-90. Operating conditions on SR 522 deteriorate the most when both SR 520 and I-90 are priced.
- The mode share analysis show HOV and transit trips to increase in the range on 3 to 8 percent when pricing is introduced on both SR 520 and I-90.
- An analysis of the travel patterns shows the following displacement of traffic resulting from pricing travel on SR 520 and I-90. In general, the reduction in daily trips on SR 520 and I-90, results in traffic being diverted to the SR 522 corridor, and on to local eastside arterials:
    - 14 to 16 percent decrease in traffic on SR 520
    - 6 to 12 percent decrease in traffic on I-90
    - 7 to 17 percent increase in traffic on SR 522
    - 5 to 10 percent increase in traffic on arterial roadways in the communities of Seattle, Bellevue, Kirkland, Redmond, and the Points Communities.

General Conclusions on Pricing and Managed Lanes

The following general conclusions on travel demand and traffic operations can be made with respect to the pricing and managed lanes concepts analyzed in this study.

- The 15 to 20 percent reduction in vehicular trips in response to pricing is consistent with the theory and observations from other value pricing studies. This results in overall improvements to the traffic flow and operations along the Trans-Lake corridor. As a point of reference, it is worth noting that this reduction in vehicle trips is comparable to the 16% increase in daily traffic observed when tolls were removed from SR 520 in 1979.

- Pricing non-HOV trips on the Trans-Lake corridors results in increased carpooling and transit trips across Lake Washington. The increases range between 3 and 10 percent.

- Pricing has an impact on travel patterns across Lake Washington. The largest displacement of trips occurs when both SR 520 and I-90 are priced – increases of 7 to 17 percent on SR 522, and 5 to 10 percent on Seattle and Eastside arterials. Traffic diversions resulting from pricing only the Trans-Lake corridor, show increases of 4 to 6 percent on SR 522, 3 to 5 percent increase on Seattle and Eastside arterials, and 8 to 11 percent on I-90.

- Congestion levels can be improved using pricing strategies during peak periods of travel.

- The revenue estimates for a stand-alone SR 520 toll (value priced) facility, in inflated year of collection dollars are:

  Year 2014: $17.7 M - $30.9 M

  Year 2030: $38.4 M - $66.7 M

- Managed lanes provide improved corridor speeds, in comparison to the general purpose lanes.

- Managed lanes operating on access restrictions and occupancy requirements alone are forecast to have excess or "un-used" capacity that could be allocated to other users. Based on the model results, there is enough capacity to allow low occupant vehicles (i.e., SOV and HOV 2 users) to use the managed lanes for a fee. This would result in increased person throughput when compared to the 8 Lane Base scenario.

- Managed lanes could provide better person throughput when compared to an HOV 3+ concept, while maintaining the same vehicle throughput.

RECOMMENDED NEXT STEPS

Since the initial results from the value pricing and managed lanes concepts tested show promise in reducing congestion and improving traffic operations in the Trans-Lake corridor, there is merit in continuing to build upon what has already been tested. The following additional steps are recommended towards this end:

- The regional PSRC travel demand models are currently in the process of being updated. It is expected that the key methodological components of this model, i.e., trip distribution, mode choice, and time-of-day analysis models will be replaced once the ongoing PSRC Model Improvement Program is successfully completed in late-Fall. It is recommended that value pricing and managed lanes concepts be tested with the Preferred Alternative using the updated regional models.

- The value pricing concepts tested in this study assumed tolls on SR 520 and I-90 only. The Washington Department of Transportation (WSDOT) has embarked on a region-wide analysis of pricing. It is recommended that the results from this study be compared with the regional analysis to better understand the travel demand interplay between pricing on one or two corridors, versus a region-wide pricing approach.

- Another option for furthering the value pricing concept would be to develop a cooperative regional pricing plan, wherein the Trans-Lake corridor could serve as a pilot demonstration project.

- Any further analysis of the value pricing concept should include a detailed traffic diversion analysis that identifies the relative impacts of traffic diversion on local arterials.

- The value pricing methodology currently being used does not include a discrete toll model. Hence the estimates of toll rates from this analysis should be viewed as a preliminary estimate of economically efficient toll rates based on managing travel demand. If value pricing is recommended for inclusion in the EIS, a more extensive effort will be required to collect appropriate survey data and develop a toll mode choice model. Such an effort is usually required for the development of investment-grade toll estimates.

- Any further analysis of the managed lanes concept should consider the potential for low occupant vehicles (i.e., SOV and HOV 2) to use the managed lanes for a fee.

- The managed lanes concept was only tested on SR 520. It is recommended that a system-wide analysis of the managed lanes concept be undertaken to fully understand how managed lanes on SR 520 would connect and operate with the managed lanes on I-405, I-90, and I-5.